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CONSIDERATIONS FOR THE DEVELOPMENT AND IMPLEMENTATION OF PDES WITHIN A GOVERNMENT ENVIRONMENT

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The purpose of this document is to serve as an aid to focus government efforts needed to ensure the development and utility of the Product Data Exchange Specification (PDES). The road to a fully realized PDES, in terms of a mainstream product, is long. Steps along the way involve development, approval and standardization, the implementation of PDES by system builders, the procurement and installation, and final acceptance of PDES by the user community. By dint of the magnitude of the task, as well as individual agency needs and objectives, it is necessary that the federal government play a role in defining and taking the initial steps. This report focuses on critical considerations in traversing such a road in terms of background, PDES fundamentals, a high level look at requirements, an operational PDES definition, a review of government sponsored projects which are related to PDES, a list of critical success factors, and finally some recommendations.

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PREFACE

This interim report describes work in support of the Air Force Wright Aeronautical Laboratories Manufacturing Directorate under contract F33615-87-C-5234 from January 1988 to December 1988. It is published for information only and does not necessarily represent the recommendations, conclusions, or approvals of the Air Force.

Gerald C. Shumaker, Computer Integrated Manufacturing Division, Manufacturing Technology Directorate, served as both Project Manager and as one of the Principal Investigators and authors. The other Principal Investigators and authors were Dr. William M. Henghold, Universal Technology Corporation, Engineering Division and Leonard Baker, Jr. an Industry Fellow to the Manufacturing Technology Directorate.

This report reflects some thoughts not necessarily original to the authors. A number of creative people provided input, both formally and informally. The author's wish to thank the participants listed in Appendix B for their contributions. Special thanks are extended to J. C. Kelly and Randy Harrison of Sandia National Laboratories. Finally, some work by Tony Day and Dick Lopatka of United Technologies Corporation was particularly helpful in focusing our thoughts.

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1.0 OVERVIEW

The purpose of this document is to serve as an aid to focus government efforts needed to ensure the development and utility of the Product Data Exchange Specification (PDES). In doing so, it recognizes the existence of a continuum of research, development, implementation, production use and test/validation needs. These needs are interwoven with the more apparent standards work, and manifest a PDES environment.

The development and eventual implementation of PDES has two aspects. One aspect involves human agreement and the other involves the technical notions necessary to bring that human agreement to fruition. Although technical considerations are presented, they are not done so in detailed terms. Instead, this document emphasizes the human agreement aspects. There are two parts to the human agreement aspect. First, there is that associated with preparing the standardized information model. Information models are not developed by simply getting a group of people in a room and writing the model down on paper. Second, there are the human agreements associated with using the standardized information model to develop operational policies for creating, using, and sharing product data. Both are important to the PDES environment.

The road to a fully realized PDES, in terms of a mainstream product, is long. Steps along the way involve development, approval and standardization, the implementation of PDES by system builders, the procurement and installation, and final acceptance of PDES by the user community. By dint of the magnitude of the task, as well as individual agency needs and objectives, it is necessary that the federal government play a role in defining and taking the initial steps.

This report focuses on critical considerations in traversing such a road in terms of background, PDES fundamentals, a high level look at where we want to be, an operational PDES definition, a review of government sponsored projects which are related to PDES, a list of critical success factors, and finally some recommendations. The background section looks into the goals and formation of the government interagency task group. PDES fundamentals are presented in terms of motivational, definitional, and organizational aspects. (Readers familiar with the why, what and who of

PDES development may wish to skip this section.) The look at where we want to be addresses various needs/objectives, notes common interests, and tries to describe a picture of what the required digital world looks like. Critical success factors are grouped under management, scope, testing/validation and communication. A short discussion is presented on each factor. The recommendations are divided according to action organization and presented in order of potential impact.

2.0 TASK GROUP BACKGROUND

The increasing importance of digital product data technology to the federal government and industry is symbolized by varied initiatives to develop PDES. The delivery of computer interpretable information shows the potential of achieving substantial productivity gains. PDES is of particular importance to the Department of Defense Computer-Aided Acquisition and Logistics Support (CALS) concept of automating and integrating acquisition and logistics support processes.

The Office of the Assistant Secretary of Defense (Production and Logistics) determined a need for a task group to coordinate the objectives and strategy of the DOD and other interested government agencies in the definition and implementation of the emerging PDES specification. An initial task group was formed and a meeting was held on 26 January 1988 in Washington, D.C. The meeting focused on information sharing among interested federal agencies. Presentations were made by representatives from the Department of Energy (DOE), National Aeronautics and Space Administration (NASA), the Department of Commerce (DOC), and various organizations within the Department of Defense (DOD).

There was unanimous concurrence with the idea that PDES is of strategic importance both for U.S. defense preparedness and for U.S. international competitiveness. The group as a whole fully endorsed the concept of working to achieve identification and coordination among the federal government's varied needs, goals and activities in the PDES arena. As a result of the initial meeting, the task group which was originally DOD specific, was broadened to formally include other government agencies on a continuing basis. Ongoing participation in task group activities was committed to by various groups as follows:

- the Department of Commerce's National Bureau of Standards (NBS, now called the National Institute of Standards and Technology or NIST),
- the Department of Defense (represented by the Office of the Secretary of Defense (OSD), Defense Advanced Research Projects Agency (DARPA), Defense Logistics Agency (DLA) and the services),
- the Department of Energy Nuclear Weapons Complex (DOE/NWC),
- and the National Aeronautics and Space Administration.

For a by-name list of participants in the original meeting and follow-on formal activities, the interested reader should see Appendix B.

Task Group continuance was based on a perceived need for a group to coordinate the objectives and strategy of interested government agencies in the definition and implementation of the emerging PDES specification. In so doing, the objectives of the interagency product definition task group were highlighted as:

- to prepare and consolidate government requirements for input into the PDES development activities.
- to provide recommendations as to technical and other actions such as needed policy changes, regulatory changes or contractual vehicles/tools (e.g., DID's, contract clauses, etc.) which the government should put in place to foster the development and implementation of the PDES specification.

As a result of deliberations on initial tasking, the task group responsibilities were delineated as:

- assessment of ongoing and planned government sponsored development activities related to PDES for the purpose of determining areas of common interest and possible cooperative ventures. Attempts were to be made to identify technology and implementation "gaps" in on-going or planned PDES-related projects for future planning purposes.
- conduct of high level assessments of implementing policies, procedures and regulations that would need to be revised to support the successful implementation of a future PDES specification. High level recommendations for the general kinds of changes that must be made to the current policies, procedures and regulations that are sought.

- conduct of high level assessment of select major weapon system and support system needs related to PDES, and highlighting recommendations as to required changes to the data delivery requirements levied on these and similar systems to effectively use PDES.
- providing technical input to the CALS steering group on a consultation basis as required.

While each of the above mentioned responsibilities will eventually be met, this document has been developed in support of the first of the task group's responsibilities. In so doing, it attempts to create a backdrop against which to measure the gaps and presents some important considerations to coordinate industrial requirements for, and technology developments to support PDES as a specification and to foster, what will be called later in this report, the PDES environment.

3.0 PDES FUNDAMENTALS

PDES normally denotes the deliverable specification resulting from a standardization process. The specification is being pursued as projects by various organizations. Both the projects and organizations are sometimes also referred to as PDES. This section presents some information that should eliminate some confusion with terminology and put readers on an even footing for the sections which follow. As a further aid, a glossary has been included at the end of this report.

The PDES endeavor is being undertaken to support the manufacturing process in its broadest sense. The resulting national standard will deal with the entire range of product data and will represent the U.S. position internationally in the quest for a single worldwide standard for product data.

The primary objective of the PDES specification effort is the development of a standardized, neutral, computer-based definition of product data which supports use of product data by different applications in an integrated manner. The definition is sometimes referred to as the conceptual schema for product data. A requirement attached to this objective is that it must be possible to implement the complete description in different user and computer system environments as available technology permits. In order to understand the objectives better, certain of the terms used deserve amplification.

Product data is intended to be more general than simply form, fit and function data. In its fullest sense, the term product data denotes the totality of data elements which completely define a product for all applications over the product's expected life cycle. A product life cycle includes design, analysis, manufacture, test, inspection, and product support. The data elements required to support a product through such a life cycle include not only the geometry, but tolerances, material properties surface finishes, and other attributes and features that completely define a component part or an assembly of parts. Very little, if any, process data is included with the exception of aspects like a heat treat specification. However, the product model should have sufficient information to directly support advanced Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) applications such as generative process planning, CAD-directed inspection, automatic preparation of cutter path data, etc. Note also, that there is a distinction between product data and business data such as those about costs, schedules, personnel, buildings and facilities, etc. as the latter are not defining characteristics of the product. It is obvious that such definitions of product data portend a huge scope and highlight a potential cause for concern. This will be discussed in the critical success factors portion of this document.

The neutral form for representing the product data is both a technical goal and an implementation necessity. It is essential for use in exchanging the data among the multiple computing systems that will be involved in the life of a product. The data must be presented in a form that is readily communicated between unlike systems. The data must be complete, adhering to a rigorous form that can be unambiguously interpreted solely from the representation. This is a particular necessity for archived models that will be interpreted at a future date by an unknown system that will be acting alone to resolve any problems.

Further, industry has found that the ability to exchange product data among a variety of different vendored computer systems is critical to a company's internal plans for integration and its external relationships with contractors and customers. This fact has been recognized by CAD/CAM users throughout the industrialized world and has given impetus to several national projects being coordinated internationally, as described later.

Computers deal with data. They manipulate data, compare data, make decisions based on data, etc. Humans, on the other hand, deal with information. There is a profound difference between data and information. Data is defined as a representation of facts which can be used for processing or interpretation. Comparatively, information consists of data, the relationships between the data, and the meanings (semantics) attached to these elements. Information can be encoded in data according to some rationale. If the rationale is known, then information can be recovered from the data. As an example, the number 1, standing alone, is data. If however, some way is found to tag this piece of data to the measure of the number of gallons of gas in a tank, information relative to some situation is obtained. PDES must provide the rationale for information extraction from product data.

Most experiences so far in sharing computerized product information between humans has been to exchange data and rely on some pre-existing external rationale for the recipient to recover information from the data. Most often, the rationale involves the human obtaining data in a visual context. This context encompasses both text and graphical data. "Graphics data" is primarily oriented toward display of an engineering drawing on a graphics device and requires a person to interpret the "information" content such as physical parts, tolerances, part features such as holes, and assembly relationships, etc. based upon an ability to "read" a drawing. The fundamental concept of PDES is the representation of directly computer intelligible "information" versus "data" which becomes information only because it is person-intelligible.

It is vitally important to understand that PDES has historical roots in but is quite different from the Initial Graphics Exchange Specification (IGES). IGES, first published in 1980 and updated in 1983, 1986, and 1988, is a data format used primarily for exchanging graphics information among present-day CAD systems. Product data expressed in IGES, including drawings, 3-D wireframe models and 3-D surfaced models, is intended primarily for human interpretation at the receiving site. The IGES effort has not focused on the specification of a standardized information model of product data. In contrast, PDES is aimed at communicating a complete product model with sufficient information content as to be interpretable directly by advanced applications, CAD/CAM or otherwise.

The PDES development and implementation approach is depicted in Figure 3.1. Here is seen a variety of applications, a series of interfaces, assorted data storage media and supporting computer (e.g., CAD, mainframe, etc.) and communication systems.

There are some basic understandings that the figure attempts to portray. These include:

- The applications will interpret the data that is presented in digital form based on a standardized PDES information model and will then use the data as appropriate to the particular application.
- The conceptual schema of the PDES model, while built to support application areas, is independent of both the physical implementation and the applications making use of the information.
- The digital data will be used in various computing environments.

The situation just presented is not unique to PDES. What makes it PDES is that the data is about products. Formulating an integrated, standardized information model of life-cycle product definition data, as opposed to the exchange problem, is the essence of PDES and is fundamentally an activity involving human agreement. This model is referred to as the Integrated Product Data Model or Integrated Product Information Model (IPIM).

PDES information will be developed incrementally. For PDES Version 1.0, the intended scope encompasses:

- geometric curves and surfaces
- solid geometry
- product structure and configuration management
- form features
- shape size
- tolerances
- finite element modeling
- drafting
- electrical
- presentation (for graphics).

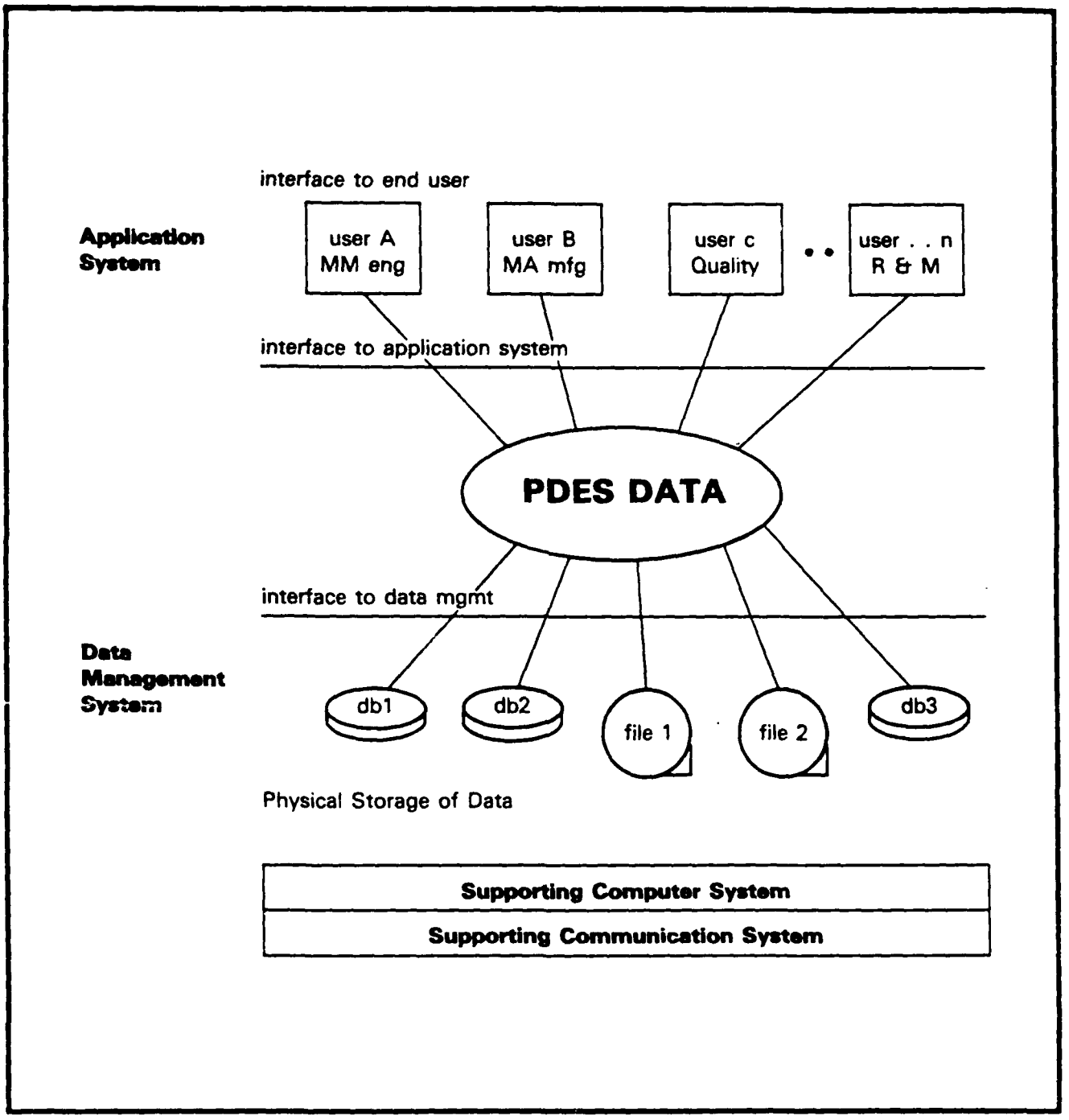

FIGURE 3.1. PDES Development and Implementation Approach

Figure 3.2 shows a representation of integrated topical models. The resulting model is depicted as a collection of overlapping models such as those relating to definition of configurations or those relating to shape and size (shown by its subsets e.g., topology, geometry, and tolerance). The model is depicted as a Venn diagram to focus on areas of commonality among the elements. Such areas highlight the need for integration.

The integrated conceptual model is the basis for all implementations. Besides driving the implementations, it forms the foundation for evaluating the compliance of any implementation with the standard. Implementations must keep in tact the meaning of the PDES content and rules defined in the conceptual model.

Four broad implementation levels, or categories, that encompass different computer architectures and implementation technologies have been defined for PDES. Levels of implementation address technologies employed and the degree of responsibility/involvement that the software has to ensure constancy and integrity. The levels are:

- Level 1 is passive file exchange,
- Level 2 is active file exchange (working from exchange),
- Level 3 is shared database access (database exchange),
- Level 4 is an integrated product knowledge base (knowledge base exchange).

Figure 3.3 shows the various implementation levels. Levels 1 and 2, shown at the top, do their job with self sufficient files (e.g., the sending and receiving systems are responsible for maintaining their own versions of the data). They differ by how actively exchange can be accomplished. Levels 3 and 4, shown at the bottom, provide for a shared data resource built on the use of databases, and use files that exist in relation to some larger entity.

Beyond implementation environment nuances, Figure 3.3 shows a much more fundamental point. The shared data model (Venn diagram) represents the critical element. It is common to each implementation and is essential for consistency of information representation. Product definition is the key. Product data must be defined, agreed upon, and modeled independent of implementation environments.

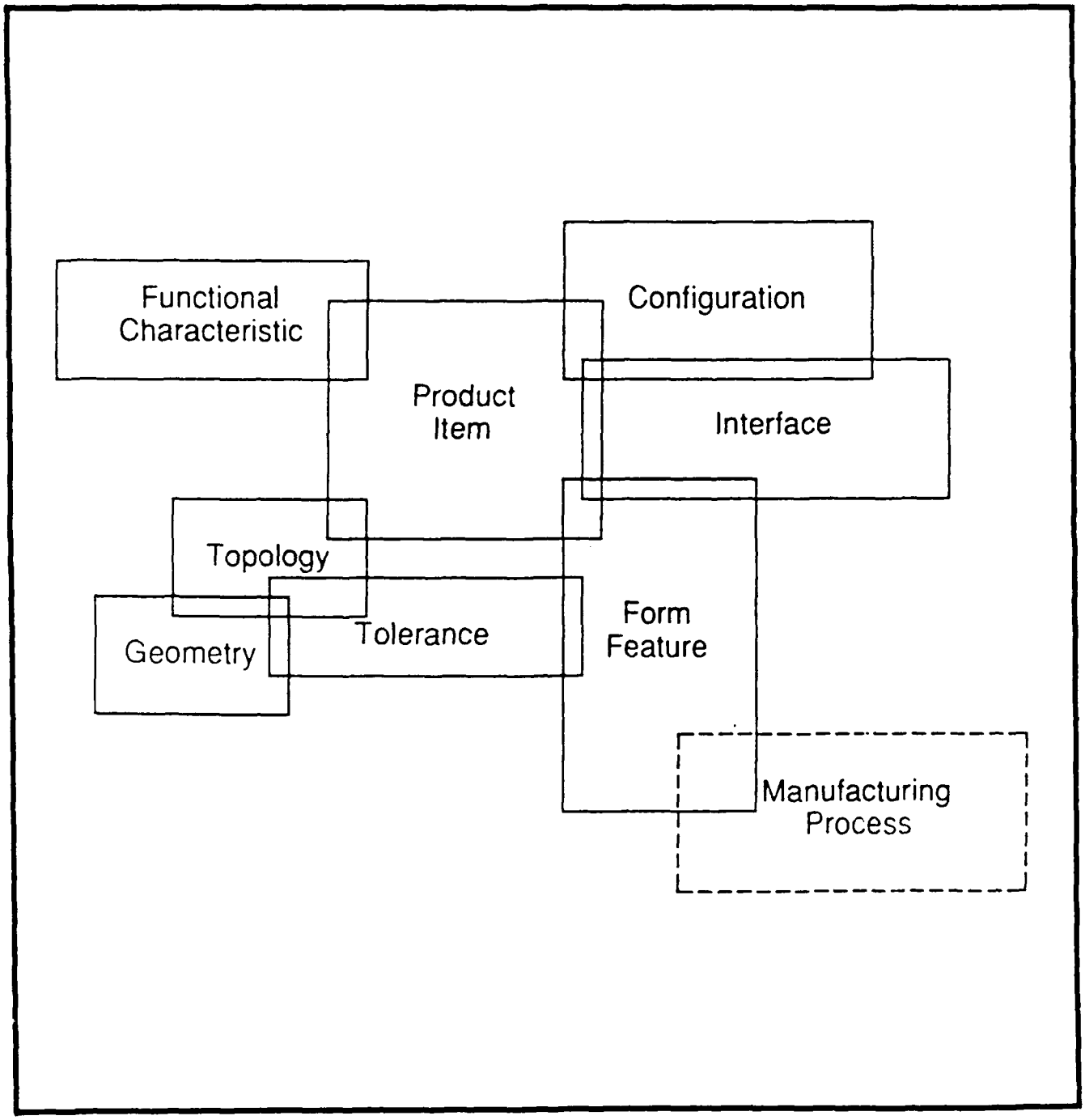

FIGURE 3.2. PDES Integrated Product Model

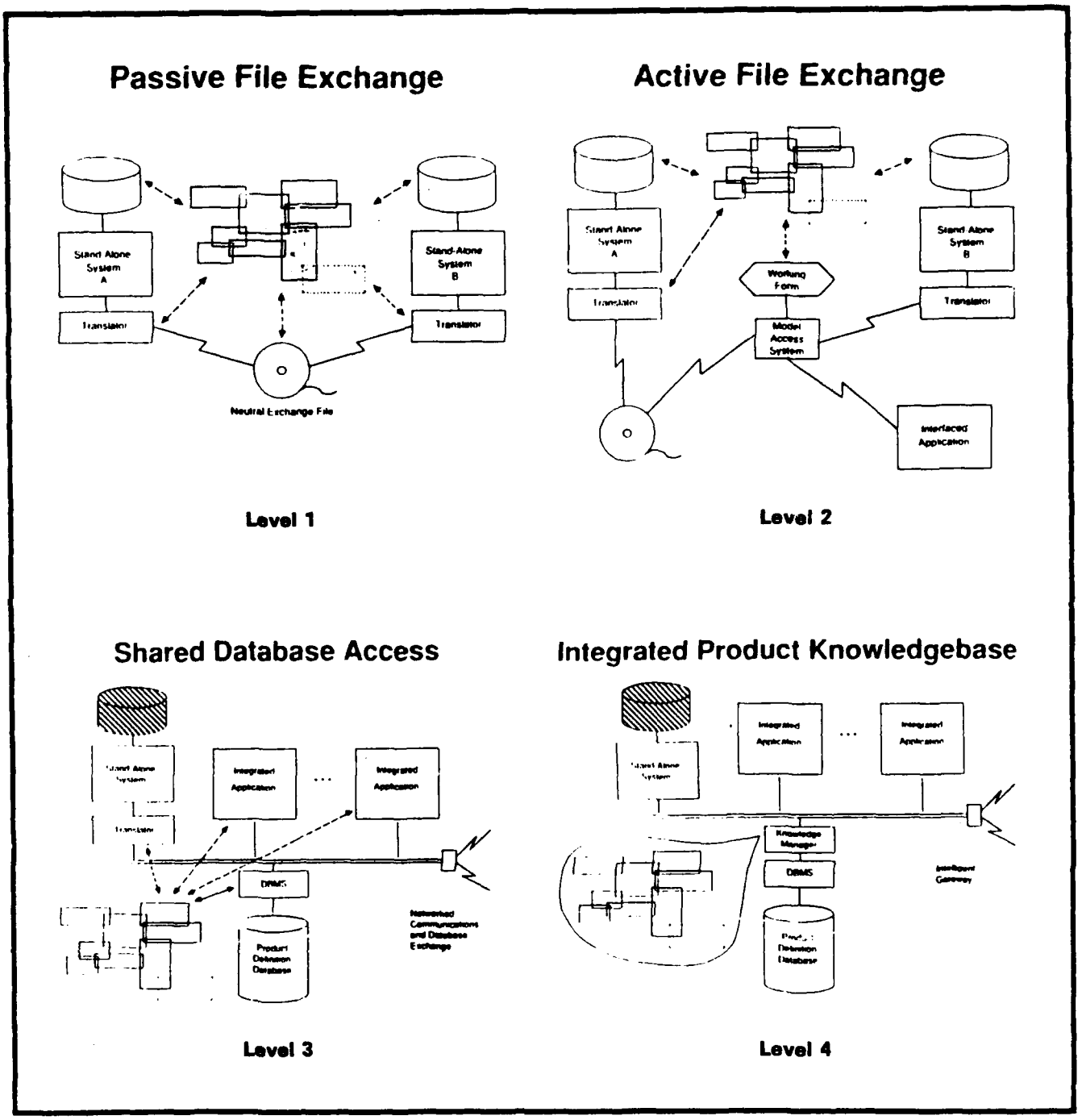

FIGURE 3.3. Intended Implementation Levels

Two nationwide initiatives, one under the IGES/PDES Voluntary Organization and the other under the recent industry cooperative PDES, Inc., are in progress to speed PDES development.

The Voluntary Organization, is coordinated under the National Institute of Standards and Technology (formerly the National Bureau of Standards) leadership and is by far the most senior in terms of time spent working the problem. This national, industry-wide group, historically rooted in 1980 IGES efforts, began work on a PDES project in mid-1984. The progress, current status and content of PDES could not have been achieved without the dedicated efforts of this group.

The IGES/PDES Voluntary Organization promotes and facilitates the development of products and works with other standards-making bodies, both foreign and domestic, for the purpose of achieving a single worldwide standard. Membership consists of approximately 730 experts from 280 companies. Five day working meetings are held quarterly with areas of work assigned to 19 technical committees. A set of bylaws define the organization and procedures. Detailed tasks and schedules are in place with the stated objective of developing, approving and publishing a testing draft of PDES Version 1.0 by December 1988. All effort is on a strictly voluntary basis.

The Voluntary Organization has primary responsibility for work to develop the draft specification. Formal promulgation as a standard is through the American National Standards Institute (ANSI) via candidacy from Subcommittee Y14.26 of the American Society of Mechanical Engineering and internationally through the International Organization for Standardization (ISO).

There are some important factors relative to the efforts of the PDES Voluntary Group that deserve special emphasis. These are:

- The voluntary approach while laudatory brings significant management challenges due to its voluntary nature.
- The group's efforts arose initially as a desire to advance technology, coupled with problems encountered implementing IGES.

- The group's published schedules call for incremental model development via integration of various topical models (e.g., shape and size or sub-sets thereof like topology, geometry, form features, etc.), over time.
- It is the group's intention that PDES and the ISO STEP (Standard for the Exchange of Product Model Data) be identical.

The newly formed PDES, Inc. is pursuing a joint industrial effort proposed for acceleration of PDES development and implementation. On 17 June 1987, a meeting was held in Washington, D.C., between 11 large U.S. industrial corporations and representatives of the Department of Defense. The purpose of this meeting was to present a DOD proposed industry initiative to accelerate the development of one of the keystones to the CALS program. That keystone is the PDES.

By August of 1987, 12 major industrial companies had responded to this challenge by formulating an Interim Executive Board to assemble the business and technical strategies for PDES development. These activities proceeded into 1988 under the title of the PDES Cooperative Project. Following the lead of the Software Productivity Consortium, under the guidelines of the National Cooperative Research Act of 1986, seven major corporations formed a corporation titled PDES, Inc., in June 1988 whose sole purpose is the accelerated development of PDES.

PDES, Inc. membership is open to any company or educational institution. As envisioned, plans call for three-year membership and similar project duration unless extended by mutual agreement. Memberships is by classes. Class I members (calling for $100,000/year dues plus two manyears technical effort each year) have voting stockholder, executive board, participation, and data rights. Class II members (calling for $50,000/year dues plus one manyear technical effort each year) have the same rights as Class I with the exception that they are non-voting board members. Class III members ($25K annual dues) have only observation rights.

PDES, Inc. has hired a "host contractor" for project management. This host contractor is responsible for day-to-day project execution and control and reports to the PDES, Inc. executive board for final direction and authority.

The stated objectives of the PDES, Inc. cooperative project are in consonance with the global objectives of the Volunteer Group to establish a definition of what information constitutes a complete computer interpretable definition of a product and to gain acceptance of the information definition in a standard information specification. However, the principal focus of PDES, Inc. is to accelerate implementation of technologies pertinent to the delivery and interpretation of such product definition information in heterogeneous computer environments.

The technical plan of PDES, Inc. depicts the first milestone deliverable (Phase I) to be completed in February of 1990. Phase I will include the product definition models of mechanical components and rigid assemblies in a level 1 and/or level 2 implementation. The NIST National PDES Testbed has agreed to perform as the testing and validation agency for implementations of the specification as it evolves.

Related software will be developed. Phase I activity will focus on software required for supporting creation and integration for information models and utilities supporting implementation of information exchange systems.

Phase II will expand the scope of Phase I (e.g. add electrical and hydraulic information to the model and extend activities from engineering to manufacturing and logistics). In addition, it will focus on a level 3 (database) implementation

This commitment on the part of private industry is not intended to replace the development activities of the voluntary IGES/PDES committees that have been pursuing product exchange capabilities since the early 1980's. Instead PDES, Inc., intends to accelerate and augment the current specification activities to insure that usable product definition exchange capabilities are in place which facilitate inter- and intra-organizational transfer of product information and meet the CALS program requirements of the early 1990's.

Fundamental differences exist between the principal groups. PDES, Inc. is presently limited to three years effort, intends that development be funded and contractually driven and has the intentions of a corporate organization. However, as can be seen is some potential for duplication of effort and public confusion of roles with the IGES/PDES Volunteer Group.

There are other groups that are working parts of the product data problem according to their particular vision of the product world. A prime example is the Navy/Industry Digital Data Exchange Standards Committee (NIDDESC). This is a cost-sharing effort of the Naval Sea Systems Command and the Marine Industry through the National Shipbuilding Research Program. Their stated goal is the cost effective development, storage, exchange and use of ship design, construction, operational and maintenance data. They seek to influence IGES/PDES development. As an example, one of their information models was recently submitted to the IGES/PDES Architecture, Engineering, and Construction Committee for review and approval.

There are also a number of projects being pursued by still other organizations that bear on PDES development and implementation. These are discussed later in the Supporting Project Review section.

From the foregoing discussion, a clear requirement for coordination is evident. As an aid, a proposal is under consideration by the Government Interagency Task Group to produce an organizational mechanism for coordination of PDES activities from formulation through final testing. The proposal calls for the generation of common documents for requirements, technology needs, implementation architecture(s) and a coordinated master plan. The requirement for coherence that such documents support is discussed further under critical success factors (Section 7.0).

4.0 A GOVERNMENT PERSPECTIVE

The federal government has definite interests relative to designing, building, procuring, operating, supporting, and maintaining products. To a greater or lesser extent, large numbers of government agencies and organizations are involved in all these product related activities. While there may be organizational or agency nuances in pursuing their interests, government organizations have both unique, as well as many of the same,

needs and desires as industry. This section provides a broad perspective on PDES development and implementation by looking at the present product data related environment and presenting some high level requirements. In so doing, examples, rather than detailed discussion on specific problems, are used to highlight important concepts.

The current product data related environment which bears on PDES development has many facets. These include:

- It is hard copy oriented.
- It is massively heterogeneous in terms of vendors and system age.
- Product knowledge is not well captured.
- Product cycles (from R&D to production) are very long and the handoff from one phase to next phase often loses information.
- Technical data packages are often in error and incomplete.
- Incorporation of change/technology upgrades is slow.
- New efforts often just automate existing methods (e.g., DSREDS/ EDCARS automates the Mosler aperture card system).
- Transfer of information to/from contractors is slow.
- Funding for "non-product" development such as PDES is limited and sometimes non-existent.
- Acquisition of improved producer technology, (e.g., new computers, CAD/CAM/CAE) is difficult, time consuming (avg. 3 to 5 years), and done in the face of ever shortening technology half lives.
- Industry concern with proprietary data rights is at odds with government desires.
- Legal reluctance to provide CAD/CAM data rather than part drawings.
- Data is replicated many places for different purposes (e.g., non-common/integrated databases).

Clearly PDES, by and of itself, cannot change all these facets. It can, however, have a direct positive impact on future operations on a wide scale.

4.1 An Organizational Example

The generalities just presented are not universal. Rather, how much of the previously described environment is applicable to various government agencies, is specific to the organization. For instance, the DOE/NWC, due to the nature of its' organization (a closed collection of eleven government-owned, contractor-operated facilities), does not have to worry about proprietary problems within the complex. Currently, in an effort to automate the exchange of product data among the various contractors, NWC is using IGES refined by their internally developed DOE Data Exchange Format (DOEDEF), and translation. As a result, they are dependent upon detailed knowledge of both the sending and receiving hardware and software, user practices and human interpretation by the next user down the line. The solution, while a creative and productive step, imposes different solutions for text and for graphics and consumes significant time and resources. Based upon their environment, NWC couches their needs as:

> "Time lasting ability to selectively, securely and directly exchange product design and manufacturing digital information throughout the development process, using a predescribed integrated database in a heterogeneous computing environment."

Meeting this need with minimal reliance on individually developed approaches and solutions, such as DOEDEF, and maximal reliance on the availability of standardized, uniform capabilities from vendors, requires the development and use of a standard such as PDES.

4.2 A Program Example

Contemplation of the present environment leads to various requirements in the product data arena. If one attempts to aggregate requirements for product data on a government wide basis, there is also a need to look at a series of specific programs in addition to organizations. Space limitations preclude such an approach here. However, an example is instructive. Consider as an example the NASA Space Station Technical and Management Information System (TMIS).

4.2.1 Background

TMIS is being developed by NASA's Space Station Program Office. The Space Station Program (SSP) is hierarchically structured as follows:

- Headquarters ("Level I") sets Program policy;
- The "Level II" Space Station Program Office, located in Reston, VA provides program-wide engineering, integration, and management;
- Four "Level III" field centers (Marshall, Johnson, Goddard, and Lewis) shoulder the responsibilities for flight hardware and software elements;
- Four major aerospace contractors, each with numerous subcontractors yet reporting to one of the above Level III centers, provide element detailed design and construction;
- Other "Level III" field centers provide augmentation with launch and other specialized support services; and
- Three international partners (Canada, the European Space Agency, and Japan) also provide flight elements.

Each engineering organization tends to have its own CAD/CAM/CAE tools which infuse their culture.

The TMIS program provides common tools for SSP technical and management capabilities to support and integrate all of the Level I and II activities and as much of the Level III activities as possible and desirable. TMIS also provides the specification of connectivity standards to other TMIS users such as the international partners. Accordingly, they are now in the acquisition process to obtain an initial delivery of about 200 CAD/CAE workstations for NASA use. An integrated environment is now operational for administrative functions (such as documentation, electronic mail, and scheduling) and will be augmented with the above mentioned CAD/CAE tools by the first quarter of 1989. These CAD/CAE workstations will be networked and interconnected with existing systems at each of the centers. Further, network connectivity will be provided to contractor sites and to international partners.

As with all government acquisitions, TMIS procurements must be performed under the full and open competition guidelines. The resultant system(s) must then be fully capable of exchanging engineering data with embedded systems in wide use at the NASA centers, the supporting contractors, and in the international partner community. To that end, the present TMIS procurement also provides for the acquisition of translator packages to/from TMIS-acquired tools and those in use at the four Level III centers which are responsible for flight hardware and software elements.

The current contracts with the four major aerospace contractors specify CAD deliverables in two forms: aperture cards and bit-image format files. Anything delivered in formats beyond these two, (such as finite element models, IGES/native format files, etc.), are presently strictly voluntary and informal. Many of the personnel involved with the overall engineering process believe that much more data structure is needed for effective engineering data exchange and that such data structures should be mandatory.

Based upon experiences with the Space Shuttle Program, NASA determined that it would serve as the repository of all "delivered" space station data. This archival responsibility was undertaken to insure timely availability of data throughout the program life cycle.

Since TMIS is intended to support an ongoing program, the implementation approach is to follow low risk strategies. This means that mature standards are sought. Emerging standards will be embraced only when their viability and cost effectiveness are demonstratable or when emerging standards provide the only exchange mechanism. Because of this application emphasis, TMIS is more likely to monitor the development of standards, evaluate their maturity, and adopt them for TMIS use than to be involved in active development of standards.

4.2.2 Requirements

The requirements to be levied by TMIS against PDES are related directly to SSP needs as follows:

- Engineering design, development, test and evaluation (DDT&E) data must be available in a usable format throughout the projected 30 year lifetime of the program.

- Data on all flight systems must be in electronic media to facilitate its transmission, on demand, to the station itself.
- PDES (and related standards) are useful for insuring the full and open competition of the initial CAD/CAE/CAM (CIM/CIE) tools of the program; these standards become mandatory for future acquisitions so as to provide data continuity.
- An efficient and effective engineering data exchange mechanism is necessary to work with the broad industry, government, and international coalitions (and their existing infrastructures, cultures, business models, etc.).
- While the government's role in space station engineering is largely in analysis, design verification and assembly, it must embrace mechanisms intended to minimize the resources required by the contractors to build the elements.
- TMIS supports a collection of databases which will contain text, graphics, compound documents, engineering drawings, and product definition data. Sheer volume suggests that these databases will be distributed and object-oriented (to reduce data redundancy). PDES is envisioned by TMIS to facilitate the creation and maintenance of such databases although such is not a present written or understood PDES requirement.
- The projected 30 year life span of the Space Station implies a need over that period to remanufacture equipment, parts, or modules, as well as a need to create (build) new pieces. We must have a way to ensure precise remanufacturing of parts (possibly by a different contractor, using radically different technology as time passes). Similarly, additional modules or add-ons must be guaranteed to fit into what already exists in use, since most design adjustments are totally unfeasible while in orbit.

4.2.3 Justification Requirements

To fully endorse PDES and make its use mandatory across the SSP, it is necessary to justify it to SSP management. Things which would aid in this effort include:

- Stability (and/or orderly evolution) of the PDES standard definition.
- Proof of concept must be documented.
- Testing suites must be developed.
- Validation procedures must be established.
- Certification of vendors/products must be available.
- Benefits must be quantifiable (savings in time, money; productivity improvements, etc.).
- Impact on current method of doing business must be identified and assessed.

These justification points highlight the road to full implementation from the perspective of this important program. TMIS is just one of many ongoing government programs and NWC one of many organizations that have product data needs. If we look beyond the particular examples, we see generally that in our dealing with products, there are compelling reasons not to simply carry on business as usual. These reasons are built upon the precepts that long term effective information sharing is required, both internal to the government for mission reasons and for our contractors to remain internationally competitive. We also see that information is different from data, and that information is much bigger than graphics. From all this, a set of high level requirements emerges. These are requirements for:

- Sharing of electronically encoded data throughout the product life cycle.
- Automated interpretation of product characteristics encoded in electronic form.
- Efficient implementation in a variety of computing environments.

This set of requirements dictates the need to establish an industry accepted definition of the data that constitute a complete product definition. It is a paraphrased statement of the PDES project mission as seen by one of the development community groups discussed earlier.

The requirements also distinguish what must be developed, from anything that currently exists. For example, simple electronic exchange of newspaper text does not qualify, since it does not deal with product characteristics (e.g., geometry), and is geared to human, not automated, interpretation.

4.3 The PDES Environment

Beyond these high level requirements, there is a fundamental idea that emerges from a look at government needs and PDES activities. This is that the development and implementation of a standardized digital product data representation and exchange capability represents fundamental change on a massive scale, and requires the convergence of several activities:

- A research base of implementing technologies.
- The development of a specification for product data representation in digital form.
- Implementations in software.
- Validity checking and testing methodology.
- Guidelines for usage in identified applications areas.
- Production use.

This convergence can be thought of as the PDES environment. It (the PDES environment) is distinguishable from and much bigger than the PDES specification by itself. This crucial distinction must be kept in mind, especially by government agencies. A concomitant to this idea is the notion that the PDES environment is so broad that only the federal government is big enough to tackle the overall coordination and management that it implies.

At the same time, the federal government also needs to deal with product data just as others do, and needs the benefits that a working product data standard would bring. In this sense, the federal government, particularly users, needs to be involved in the PDES specification too, right along with others.

One final point emerges from a look at government requirements leading to a fully realized PDES environment. The point is; we have far to go beyond the immediate technical challenges. If the PDES specification and associated hardware and software products were available today, could the government use them on a broad scale? The answer is clearly "No". Needed procurement changes and inherent lag times, potential legal issues, infrastructure resource and procedural voids, etc., must be dealt with. It is not wise nor feasible, at this time to simply call out PDES in contracts. The government must prepare to receive PDES product data and to be an active, information sharing element of the PDES environment. The work required to achieve this state is nontechnical, but critical to the overall process.

5.0 PDES DEFINITION

We recognize that PDES cannot be all things to all people and that in the final analysis the specification and subsequent standard must be defined in highly technical terms. We can, however, present a high level definition that helps speed specification development and insures eventual utility. Such a definition can aid by providing direction to define future PDES information requirements, by helping to identify the technical, organizational, and economic voids in present PDES activity, and by helping to focus current and future programs (both government and industry funded).

Specifically, PDES must be a validated description of the logical structure and meaning of product data that:

- supports applications programs which in turn support design, manufacturing and logistics users.
- will be implemented using vendor supplied DBMS-like systems.

Specifically, PDES is not:

- applications system software,
- data management software,
- user interface software,
- communication interfaces/protocols,
- a specific type of implementation environment.

The above is a recasting of the concept that, as has previously been noted and shown in Figures 3.1 and 3.2, PDES supports, but is independent of application and implementation specifics.

Further PDES is a harbinger of computer systems which truly support people in the way product-based business should be accomplished and as such it must:

- Support the management of products as opposed to management of the present day manifestations of products, namely drawings and documents
- Support "hands off" exchange of information with a minimum of human interpretation required across heterogeneous systems
- Be computer sensible
- Have the capability to interrelate a broad range of data in a temporally efficient manner. This implies support for all four implementation architectures including those for physical file exchange and those for direct application access to product data. Data interactions should include engineering to manufacturing, (e.g., as with technical description to bills of material or technical description to inventory, etc.), manufacturing to logistics (e.g., how things are assembled could be reversed for disassembly, etc.) as well as associated feedback.
- Have a single (common) logical representation of data with derivable application views. This is "core" data from which implementors can derive specific needs to support specific users.

The requirements listed above are simply stated but they have some profound management implications associated with them. The following discussion provides just two examples of such implications.

The management of products as opposed to drawings etc., forces changes above and beyond just automating the current environment. This represents a discontinuity in how business is done. A pragmatic look at legacy systems, such as those relating to IGES, when coupled with the discontinuity, dictate the need for complementary strategic planning (a migration path). On a related but somewhat more specific level, the management of products dictates that assembly can't long be ignored in PDES efforts or else we have defacto management of parts.

With paper as the common denominator for product data representation and exchange, the buyer of the data is shielded from the technology used by the contractor to produce the data. Computer sensibility and hands off exchange imply that the government must realize that there is a much tighter coupling with the technology, that there will be concomitant needs for education, etc. The government must become more technically involved. For example, government users must be part of model development and validation on a continuing basis.

6.0 SUPPORTING PROJECT REVIEW

As has been indicated previously, the government interagency product definition task group was formed to coordinate the objectives and strategy of interested government agencies in the definition and implementation of the emerging PDES. As a part of their activities, the task group assessed ongoing and planned government sponsored development efforts, related to PDES, for the purpose of determining areas of common interest and possible cooperative ventures. Particular emphasis was given to the identification of technology and implementation "gaps" in ongoing or planned PDES related projects to assist in future planning.

This section provides a synopsis of project review activities. The main body consists of two sub-sections. The first sub-section provides a look at the process employed. This is followed by a discussion of results wherein some conclusions are also offered. Write-ups for the individual projects which were reviewed are presented in Appendix A. Readers desiring more detailed information than that provided in the appendix should contact the individual project government point of contact with their request for information.

6.1 Process Overview

The initial focus of the review process was on project selection. At the first task group meeting, agency representatives were given an opportunity to describe current or planned PDES-related activities. This allowed them to put forward, to the group at large, those projects within their purview that were government sponsored and related to PDES definition and implementation. The term "related" was broadly interpreted to include projects on the critical path of a coherent approach to the establishment

of PDES. This allowed for the inclusion of research and development activities, as well as endeavors that obviously fell short of supporting computer interpretable exchange, but which might present lessons learned relating to infrastructure needs, etc. A total of twenty-seven projects were included for review.

The methodology employed in gathering project level information involved three steps. These were: 1) a structured interview of the principal government point of contact for the project; 2) a write-up of information obtained during the interview; and 3) feedback to the project expert to insure that his or her intent had been fairly captured.

In order to facilitate the information gathering process, an interview guide was developed. The guide was explanation-based and included an attempt to partition the projects according to the PDES view of information scope and implementation environments. Scope information sought to determine if the project addressed any specific class of topical data (e.g., shape/size, configuration), any specific class of product (e.g., electrical, mechanical), or a specific portion of the product life cycle (e.g., design, support). Implementation information categorized the project according to the PDES environment targets and looked at the resource, procedure and testing issues required for true implementation. Information relating to technology transfer and standard management-type indicators were also gathered. The latter included key personnel identification, short objective statements, schedule considerations and resources committed to the project.

6.2 Review Synopsis

Prior to presenting a synopsis of the review of the government sponsored efforts, some cautionary notes are in order. First, there is an inherent danger in loss of information during the process of project generalization. Technical nuances sometimes demand detail. For instance, just because a part is mechanical says nothing about its size, shape, inherent manufacturing needs such as tools for assembly, etc. Next, all projects are not alike in terms of resources (e.g., $300 thousand versus $300 million), thus two "votes" for working logistics issues do not necessarily carry the same weight. Further, just because a project carries an IGES tag does not mean that it does not support the basic tenant of the PDES environment. Finally, based

on scope considerations, the projects reviewed do not form an exhaustive list of government efforts that could be construed as being "related" to the development and implementation of PDES.

Table 6.1 lists the projects reviewed, the principal way they support PDES and provides a short comment concerning the project's basic function. Table 6.2 provides a spreadsheet-type look at the information scope, implementation and technology transfer information for the projects. The columns in Table 6.2 correspond to the rows in Table 6.1 (e.g., column 21 contains information related to the UTAH ALPHA-1 project).

A study of the tables, sometimes augmented by project level detail, leads to the emergence of some key points.

1. The primary support relationship for the projects reviewed can be roughly termed as infrastructure/lessons learned. While the road to an implemented PDES environment still stretches far into the future, there is a wealth of information, both technical and procedural, available about obstacles which are likely to be encountered along the way. Although a specific implementation will have to address detailed infrastructure needs, there is much to be learned from past related efforts. The presently disjointed information should be utilized in a coordinated fashion. The benefits of coordination apply at the policy level, as well as the technical level. For example, a recent report from the Army CALS project on information exchange standards evaluation reaches the following conclusion with respect to MIL-D-28000/IGES products:

   > " The need to have contractors deliver product definition data conforming to MIL-D-28000 specifications, combined with the present inability of most CAD systems to support the specification, create a need for near-term alternative solutions to IGES implementation problems."

   From a simple replacement using MIL-X-XXX and PDES, in place of MIL-D-28000 and IGES, it is obvious that the same type of situation will occur as the PDES environment gradually emerges.

TABLE 6.1. Support Synopsis

	ORG	PROJECT	SUPPORT RELATION	
1	DOC	AMRF	direct for test	Models a subset
2	DOD-A	CALS Support	potential	In acquisition-
3	DOD-A	DSREDS	infrastructure	Storage and ret
4	DOD-A	IGES Eval	infrastructure	Source for pote
5	DOD-A	MIDS	indirect	Demonstrates di
6	DOD-AF	CALS Reprocurement	potential	May help define
7	DOD-AF	CALS Test Network	lessons learned/potential	1840A testing.
8	DOD-AF	Digital Product Models	direct for acquisition community	Will help define
9	DOD-AF	EIS	indirect/potential	Design focus fo
10	DOD-AF	GMAP	past direct effort	Supporting techn
11	DOD-AF	IDS	indirect/potential	PDCM could be PD
12	DOD-AF	IISS	indirect	Support shared d
13	DOD-AF	VHDL	none	A human readable
14	DOD-DARPA	DICE	research base	Looks at constra
15	DOD-DARPA	First Cut	research base	Aimed at design/
16	DOD-DARPA	Utah ALPHA-1	research base	A research testb
17	DOD-DLA	APDES	potential	Provides a file
18	DOD-DLA	MEP	indirect/potential	Provides capabil
19	DOD-DLA	MPIS	lessons learned/intrastructure	Provides prototy
20	DOD-N	CAD II	potential	Umbrella for pot
21	DOD-N	MCM-1	lessons learned	Special purpose
22	DOD-N	RAMP	direct/potential	Slated to use PD
23	DOD-N	SSN21	lessons learned	No direct PDES t
24	DOE	DOEDEF	lessons learned/infrastructure	IGES-related but
25	DOE	PDI	direct	Some models are
26	NASA	Design Knowledge Capture	research base	Trying to captu
27	NASA	TMIS	direct/infrastructure	Would implement

1 of 2

COMMENT
bels a subset of PDES. Non-production testbed (as a working research facility).
acquisition-details unavailable as of this writing.
orage and retrieval using raster scan on optical disk. No intended PDES content as yet.
rce for potential impacts to the infrastructure. Now strictly IGES related.
onstrates distributed data base access for parts, status and control.
help define future requirements for PDES format for reprocurement technical data packages.
DA testing. Looking at operational impact. Potential for PDES files if modified.
l help define PDES requirements related to level III production drawings.
ign focus for VHSIC. Developing some object-oriented models. Potential to impact level 4.
porting technology plus partial model development for Version 1.0 incorporation.
M could be PDES configuration management. Potential for sustaining engineering function.
port shared data concept. Provided basis for later projects (e.g., IDEF1X, etc.).
uman readable design tool which is an IEEE standard.
ks at constraint management of facts in design of product life cycle needs.
ed at design/manufacturing integration.
esearch testbed for experimental geometric modeling.
vides a file specification for apparel geometric data.
vides capability to emulate form, fit and function of microcircuits.
vides prototype for direct access to electronic and mechanical parts data bases.
rella for potential vendor interest. CAD/CAM intensive vice PDES.
cial purpose CAD. A modest effort aimed at a single product model.
ted to use PDES like subsets for input to manufacturing. Potential test sights.
direct PDES tie; however, works transfer issues (text and IGES).
S-related but works implementation issues and technology voids.
e models are directly incorporated in PDES.
ing to capture design intent for space station in computer interpretable form.
ld implement PDES in SSP support if available.

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TABLE 6.2. Scope, Implementation and Technology Transfer Crosscut

	1	2	3	4	5	6	7	8	9	10	11	1.
INFORMATION SCOPE:												
Aimed at Specific Class of Topical Data	NO		NO	NO	NO	NO	NO	YES	NO	YES	NO	NO
Shape/Size								x		x		
Aimed at Specific Class of Product	YES		NO	NO	NO	YES	NO	YES	YES	YES	NO	NO
Electrical									x			
Mechanical	x					x		x		x		
Aimed at Specific Portion of Product Life Cycle	NO		NO	YES	YES	NO	NO	YES	YES	NO	YES	NO
Design				x					x		x	
Analysis												
Manufacturing				x				x				
Support					x						x	
IMPLEMENTATION:												
Environment Target:												
Nonspecific												
Passive File			YES	YES		YES	YES	YES		YES		YES
Active Exchange					YES		YES	YES		YES		YES
Shared Database	YES								YES		YES	YES
Integrated Knowledge Base									YES			
Required Resources:												
Demonstration Only, None Required	N/A			N/A	YES	YES		YES	YES	YES	YES	
Defined	N/A		YES	N/A			YES					YES
Planned	N/A		YES	N/A			YES					YES
Programmed	N/A		YES	N/A			YES					YES
In Place	N/A		YES	N/A			NO					YES
Testing:												
Scenario(s) Defined	YES		YES	N/A	NO	NO	YES	NO	NO	YES	YES	YES
Test Plan Developed			YES	N/A	NO	NO	YES	NO	NO	YES	NO	YES
TECHNOLOGY TRANSFER:												
Contractor Personnel Actively Participate in PDES Activities	N/A		N/A	YES	NO	N/A	YES	YES	YES	YES	YES	YES
Government Personnel Actively Participate in PDES Activities	YES		YES	YES	NO	YES	YES	YES	YES	YES	NO	YES
Provide Briefings to PDES Community	YES		NO	NO	NO	NO	NO		YES	YES	YES	NO
Provide Results to PDES Community	YES		NO	YES	NO	N/A	NO		YES	YES	YES	NO
Provide Contract Deliverables to PDES Community	NO		NO	NO	NO	NO	NO		YES	YES	YES	NO
Receive Briefings from PDES Community	YES		NO	NO	NO	YES	YES	NO	NO	YES	NO	NO
Receive Results from PDES Community	YES		NO	NO	NO	YES	YES	NO	NO	YES	NO	YES
Receive Project Deliverables from PDES Community	YES		NO	NO	NO	NO	NO	YES	NO	YES	NO	NO

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NO	NO	YES x	NO	NO	YES x	YES	YES x	NO	NO	YES x	NO	NO	YES x	YES x	YES x	NO
YES x	NO	YES x	YES x	YES x x	NO	NO	YES x	NO	YES x	YES x	YES	YES	YES x	NO	YES x	NO
x							x			x	x	x				
		YES			YES		N/A			YES			YES			
	YES YES					YES			YES	YES	YES	YES				YES
YES	YES		YES YES	YES										YES	YES YES	
YES		YES	YES	YES	YES	YES	N/A	YES		YES					YES	
	YES YES YES YES								YES YES YES NO		YES NO NO NO	YES YES YES YES	YES YES YES YES	NO NO NO NO		YES YES YES NO
YES NO	YES YES	NO NO	NO NO	NO NO	NO NO	YES NO	NO NO	YES YES	NO NO	YES YES	YES NO	YES YES	YES YES	NO NO	NO NO	NO NO
YES	YES	NO	YES	NO	NO	YES	NO	NO	N/A	NO	YES	N/A	N/A	N/A	YES	YES
NO	YES	YES	NO	YES	YES	NO	NO	NO	YES	YES	YES	NO	YES	YES	YES	NO
YES YES YES	NO NO NO	YES YES NO	NO NO NO	NO NO	NO NO	NO NO NO	NO NO NO	NO NO		NO NO NO	YES YES YES		YES YES N/A	NO YES NO	NO NO NO	NO NO NO
NO NO NO	NO YES NO	YES YES NO	NO NO NO	NO NO	NO NO	YES YES YES	NO NO NO	NO NO		NO NO NO	YES YES YES	NO NO NO	NO NO NO	NO YES NO	NO NO NO	NO NO NO

2. While the aggregate of the project resources is considerable, there is little direct government support to PDES development. Further, the support which exists is essentially uncoordinated. Aside from some DOE work, the availability of the AMRF for non-production testing and an Air Force project focused on ATF efforts, direct support is either nearing close out or historical.

3. Most of the projects were not aimed at a specific class of topical data. The only exceptions were two efforts which focus on shape/size data and one focusing on geometry. While the utility of topical data and the use of associated topical models is debated in the PDES development community, it appears that more diverse topical investigations are needed.

4. Of those projects aimed at a specific product class, the mechanical class is predominant. This is to be expected given the historical IGES roots of much of today's exchange technology. However, mechanical product leaning does not imply duplication, as the classification "mechanical" is extremely broad. It does imply that government planners should look at the mechanical predisposition from the standpoint that they are sure that total mission needs are being met in light of different technical and application challenges (i.e., 2 versus 3 dimensions, technology half life versus system support life, potential benefit, etc.).

5. Of those projects aimed at life cycle specifics, the design portion of the product life cycle dominates. Analysis was not singled out at all and support appears under-represented. In general, it appears that more life cycle balance would be beneficial.

6. Although a number of projects perform aggregationally similar tasks (e.g., they look at such things as distributed database management in a heterogeneous computer hardware environment etc.), no overlaps were found at the project execution level. For instance, the IDS program is presently focused on support engineering as applied to a limited subset of mechanical parts, while the EIS program has an electronics engineering and design focus. Both however, seek to develop and use information models to provide data exchange and tool

interoperability in a heterogeneous computing environment. The benefit potential for these and similar programs could be improved by better coordination. Such coordination should be formal and continuing.

7. There are clear implementation gaps that are related to both infrastructure and technology needs. Little implementation, and hence production driven validation, is as yet intended. The RAMP project has some implementation potential but is presently leading PDES development by a large margin. The DOEDEF project, although IGES-related, provides the most comprehensive potential in terms of providing an implementation path to the basic capability of a PDES environment. Of particular note is that there are no intended shared database implementations outside the research community. The Integrated Information Support System (IISS) project has led to some implementations but these are modest efforts existing at contractor plants. They do not portend the total product data exchange implementation problem scope.

8. Technology transfer is occurring, but could be improved with respect to the PDES development community. Many of the same contractors either execute projects, sit on project industry review boards, and/or participate in IGES/PDES volunteer activities. As a result, informal technology transfer activities occur. This could be improved by more formal mechanisms (e.g., submit selected contract deliverables to the PDES, Inc. support contractor, etc.). Certain very important groups are missing out entirely. The National Center for Manufacturing Sciences is a government and industry sponsored consortium supporting the advances of manufacturing sciences for U.S. industry. Presently they are ignorant of the technological impact and strategic importance of PDES. This ignorance limits the advances of the PDES program and limits the benefits of their funded activities.

9. During the review process, a number of projects emerged that for one reason or another were not looked at. Examples include projects that were under consideration, but unprogrammed (e.g., the OPIKA project aimed at an object-oriented PDES level 4 demonstration), planned but internal (e.g., the Army's Next Generation Engineering

Data Management Study), and smaller efforts in the research base (e.g., the Air Force design by features effort). To gain maximum benefit, technology transfer efforts must be thought of as a process as opposed to an event.

10. Technology transfer would also benefit if direct technical support could also be improved. NIST and DOE/NWC personnel provide a significant portion of the PDES development technical core. DOD support on the other hand is a bit haphazard and tends toward the management arena. A stable, internal, critical mass of technical DOD specialists, who have the time, travel funding and direction is missing. They are particularly needed if infrastructure requirements are to be considered at the detail level.

7.0 CRITICAL SUCCESS FACTORS

Attempts to progress from the present day state of affairs to an implemented specification will be made in the face of considerable complexity. This section attempts to highlight the critical success factors that must be addressed. While there is some overlap, the factors have been grouped under four broad headings. These are management, scope, testing/validation and communication.

7.1 Management

Management success factors include removing both planning and organizational impediments. Efforts to date have broadly addressed specification development based on ground swell vice critical issue management.

While PDES will be developed in an evolutionary manner, it cannot simply evolve naturally. PDES development must be driven by an overall strategy to achieve specific target improvement opportunities based on critical need. It needs top down direction as well as the current bottom up development. It must focus on high leverage data from critical applications which, through testing, can be refined, extended, and implemented as part of the strategic plan. A strategic plan is necessary to look at or provide:

- clear objectives that distinguish standards, research and development, implementation and production use and benefit.
- a clear position on upward compatibility which weighs the potentially growth retarding aspects (e.g., impedes specification remodeling and refinement) with the reality of business dependent implementation and then establishes growth paths of future versions.
- a clear statement of the context and purpose of each topical model within a defined overall specification.
- statements which define what is expected for the various involved groups (e.g., defines the role and expected effect of a voluntary standards effort on the problem, similarly for PDES industry cooperative, CAD vendors, DBMS vendors, computer vendors, etc.)
- a method of managing the content and development of the previously mentioned Venn diagram.
- a methodology and procedure for the development of the PDES specification which is agreed to by those involved in the specification project; specifically, should the emphasis be placed on developing and validating application area information models, then integrating the application models and validating to obtain a PDES standardized information model, or should the emphasis be placed on developing and validating topical area information models, then integrating the topical models and validating to obtain a PDES standardized information model from which application views can be derived. In either case, the primary requirement must be to support end users' application needs.

A critical part of both implementation and strategic planning is the need to ensure coherent strategies between the current IGES and PDES efforts. The current expectation by many individuals is that IGES will be replaced by PDES and it will solve their size, performance and associativity issues and take the form of a faster, stronger, more powerful IGES. This implication must be addressed. Eventually, use of IGES should be able to be accomplished within the context of the conceptual IPIM, which is the essence of the PDES specification. In some cases, use of IGES could be "stand-alone" as when the user wishes to transmit graphical data only and already has an IGES capability.

The tasks leading to PDES standardization are too large for any one company/organization to address in a global manner. The government cannot expect to have a solution simply vended. Nor can it expect a PDES environment to emerge phoenix-like from a collection of efforts.

The inception of PDES was grass roots, based upon some far sighted people who were looking to identify the real need for product information independent of current storage and transmittal media. As a result, the main PDES efforts have been "volunteer efforts". This terminology implies dedication and also means the effort is noncontractual for the participants and that they work on items of personal interest as opposed to strategic criticality (e.g., the speciality of the information in the CAD/CAM arena may be over focused upon). No "must do" commitments are required by those in the PDES committees. This creates a situation that limits PDES management leverage, maintenance of target dates, balance of technical strengths, and resolution of conflicts. PDES members operating without contractual commitments respond as best they can in light of their other commitments which may be contractual.

In addition to problems on the execution level, PDES must deal with standards organization and procurement impediments. After lengthy development, the minimum approval time, including mandatory public review cycles, for a national standard is approximately 13 months. Thus the old saw about "yesterday's standards delivered tomorrow." This inhibits the use of the standard by government, particularly in light of procurement lag times and excessive system development times. The standardization process impedes the development of PDES in the light of fast changing technology. The process of developing an industry consensus standard must be improved to allow higher quality results to be achieved in a shorter time frame and those quality results inserted into systems.

In summary, PDES must be managed according to a plan by an organization empowered to define and ensure the completion of the whole job. This job encompasses research and development, standards work, testing/validation, implementation and production use.

7.2 Scope

The "as-advertised" scope of PDES is virtually unbounded. Product data, taken in its broadest sense, which can support all applications, is mind boggling. PDES development must be driven by an overall strategy to achieve specific target improvement opportunities rather than be driven by specific technical interest. The present scope is so broad that its ultimate achievement in the foreseeable future is highly doubtful. Implementing the model in strategically chosen "bite size chunks" is essential.

The broad scope has its own large logistics tail as with its tremendous documentation burden. Needs range from integration of material from the many subcommittees, to final specification, to proof reading, to publishing, to change control procedures after publication for documentation maintenance, to training and publicity material. This presents a formidable set of tasks, particularly for a volunteer community to handle.

The requirement for an ability to interrelate a broad range of data is necessary in order to achieve the most from the potential benefits of shared information. However, such breadth cannot be achieved over night. What is needed is a scoping down, based on focused direction and prioritization of efforts. Extension of models must be via leveraged data based on critical application potential.

While hearkening back to the planning need, there is a lack of end user requirements specifications that PDES is intended to satisfy. Thus, the easy slip to universal scope as opposed to a look at the specific people whose specific problems we are trying to solve. While the thrust of PDES has been to define the core requirements of the specification, these core requirements are not focused on those areas that have a real requirement for PDES. There has not been a balance between the PDES scope and defined needs nor has there been an orientation toward application needs.

In summary, the final broad scope must be reached in a series of integrated, prioritized, proven steps.

7.3 Testing/Validation

The criticality of testing and validation cannot be overstated. The PDES voluntary technical committees are engaged in the process of developing a testing draft Version 1.0 specification with the capabilities for geometry, mechanical parts, tolerancing, FEM, presentation and drafting. These applications are being documented in a succession of testing drafts, each adding increasingly more complex data structures to the PDES development. Two testing drafts were published in 1987 and two more are anticipated in 1988. The work has made progress toward the goal of a Version 1.0 specification in 1988 but has also identified many problems which cannot be fully answered without implementing and testing actual software. Resources are required to solve the problems.

The PDES specification must not be developed and published by an open-loop process. A general notion of validation which involves "real" environments and dedicated test beds should be developed and applied before the specification can be considered official. Validation of the standardized information model consists of ensuring that the product data needs of validated application models can be supported. That is, the standardized information model is shown to be robust enough to support the minimum range of application models, where minimum is based upon some measure of criticality and potential business reward. Without the former mission priorities may suffer and without the latter potential vendors simply won't be interested. The procedure takes individual models, which exist to varying states of completeness, to integration beyond the rudimentary and uses them in key life cycle scenarios.

The end user perspective is vital from the beginning and must be visible in the testing/validation area. This may compensate for a perceived lack of user input during standards development. PDES end-users must be able to deal with the product data in their terms, using their rules. PDES must provide a tested way to look through end-user glasses.

Testing can be of three basic types. These have differing goals such as to:

- Demonstrate the completeness of data descriptions which may not really work the application to a great depth and have no planned technical breakthroughs.
- Demonstrate an implementation technology which has technical advances (e.g., progress up the implementation levels 1-4).
- Demonstrate an application using the PDES standardized information model such that a working solution is obtained using application specific terminology and rules.

Each type has unique needs in terms of resources, methodology, etc. However, all types of testing are envisioned as being necessary to foster the development and implementation of a PDES environment.

The need for test beds for implementation is obvious. These test beds need to go beyond the prototype systems [e.g., Geometric Modeling Applications (GMAP), Integrated Information Support System (IISS), Integrated Design Support System (IDS)] to those used on a production basis. A thorough testing program minimizes the danger of life long patches. Without it, in some of the more technical based PDES areas, there looms the possibility that initial results get cemented in prematurely. Schedules dictate that something be published and then the standards process dictates that things not be changed if possible.

The previously discussed scope issues fall over into testing. Because of the size and scope of the PDES specification, there is no one system that could today test and validate using an entire PDES model. Subsets of the specification will have to be defined.

Current technology cannot test the entire schema even if it has been defined in subsets. Current technology lags what is being specified. Existing CAD/CAM systems utilize only a portion of the PDES specification, primarily geometry and topology. Some newer systems use some features and tolerances. The test cases will need special software for their creation. For some portions of the PDES specification, there are not applications available for testing.

7.4 Communication

Just as the process of sharing product data through implementation is communication intensive, so to is the development process. Managers, developers, implementors and users of PDES need to be placed on a more common footing. There is not a clear understanding of the goals, objectives, consequences and benefits of PDES outside the core development organization. Too much confusion exists. The commitments of resources needed for developmental support and adoption will not be made without improved understanding of benefits and goals.

There is a particular need for communication with management, both government and industry, as to what PDES is, what it will or can do, and what benefits can be derived. Critical elements of such communication are:

- it must be a non "jargonese" approach that is understandable outside the development community. Management does not often deal with nor appreciate schemata and many other data processing terms.
- it must not trivialize the magnitude and complexity of the problems being attacked. IGES has been hard enough (it still has performance issues relating to size, speed and multiple representations or flavors) and PDES is potentially much more than a better IGES. There is a need to build credibility through communication.
- it must be accompanied by good examples which somehow portray the pain (measured in terms of dollars) of how things are done today versus how they could be.

Improved communication with management shows that while not necessarily providing a panacea like solution to environment shortfalls, a PDES environment brings significant benefits. A typical example could be found by looking at the change process and focusing on interactions among engineering, manufacturing, quality and logistics in todays largely informal, meeting intensive, data/information deficient world. For the simple task of increasing or opening up a diameter to meet some standard or producibility goal there are requirements to:

- retrieve a parts number, drawing(s), and several CAD/CAM files that describe the feature

- look at assembly impact to check mating parts
- check for the part having multiple uses
- check on requirements for a new engineering analysis (e.g., stress or weight checks)
- check on requirement for retest
- check on reprocurement data impact
- work through the effectivity trail
- check on manufacturing impacts for tooling, NC programs, vendors, plans (process/capacity/scheduling), inventory, materials, etc.

The idea demonstrated is that this simple process which occurs thousands of times during major systems development can be streamlined via PDES to achieve aggregationally significant cost, time and quality benefits.

Communication is also needed from the government. Although, based on intended Navy CAD buys, CALS program objectives, Air Force Manufacturing Technology projects, etc., considerable government interest is evident in PDES, roles and internal government coordination needs clarification. Interested agencies need to determine a common direction and establish coordination as a forerunner and impetus to improved industry coordination. A clear requirements statement relating to such things as disparity of user capability, hands off environment, large volumes of data, etc. is needed. The developers need to know what the government believes success on their part would be and what the government expects the developers to do such that it can see and evaluate how much progress is being made.

One point relating to communication deserves emphasis. It is necessary for the government to eventually communicate in technical detail leading to a set of government required PDES standards. (e.g., determine data fields required in DOD PDES files, determine geometry required such as wireframe, surfaces, solids or BREP, CSG, faceted, determine drawing rendition requirements, approval requirements of electronic data (signature block, etc.). This requirement for detail is critical. For instance, without DOD standards on PDES delivered files, the CALS objective of procuring (once) universal part data that can be used in design, manufacturing, publishing, training, etc., will not be met. Project managers may omit functional data on electronic assemblies to save money during funding crises. Contractors may only deliver wireframe data. CSG and BREP geometry will not be exchangeable

both ways. Standards should be developed and enforced for a core of data on mechanical, electrical, and other types of products. Otherwise when information is needed in later life cycle times, it will be found missing.

A final area that needs government communication relates to technology transfer. Currently, developers are not permitted to generally share the technology internationally to develop the conceptual schema. Due to the global nature of most U.S. industries, it is imperative that the national and international standards dealing with the exchange of product definition data be the same. However, the restrictions imposed by congress on the export of technology and protection of information have made this impossible in the ISO world.

8.0 RECOMMENDATIONS

With a perspective presented and critical success factors enumerated, recommendations are in order. In making recommendations it is necessary to highlight the action organizations. The PDES world is organizationally amorphous. For the purpose of this document there will be action organizations for the federal government and for the PDES development community. The former will involve both broad aspects requiring multi-agency participation and agency specifics. The latter will involve both the IGES/PDES Volunteer Group and the PDES, Inc. In all cases, extensive coordination is in order.

The government should:

- Provide a national focus on the requirements for a unified PDES environment, i.e., getting a coordinated perspective on and giving coordinated direction to R&D, product development, testing, etc.
- Establish an internal PDES management structure which will act as integrator/clearinghouse for both government and private/industry funded PDES related developments. This structure must have sufficient management visibility and control to define and insure the completion of the government critical portions of the whole PDES job.

- As part of the management structure, designate and support a lead organization to coordinate activities and projects aimed at fostering the PDES environment.
- Provide resources to facilitate development, in the form of directed funding, and as specific top-down directions to PDES efforts. Resources should be contingent upon development community progress measured against an overall strategic plan and achievement of specific tactical milestones beyond the passage of time.
- Specifically fund PDES test beds for proof of concept and certain aspects of validation.
- Formulate a realistic, coordinated plan for government use of standards for product data that can take the activities of the PDES environment into account. Perhaps this task could be accomplished by using the Interagency Task Group as a formal working group for plan development and coordination.
- Provide government requirements for PDES to the PDES development community. The requirements should specifically reflect a few prototype, high-leverage, major problems and scenarios that are "do-able" in the near future to help focus and demonstrate the value of PDES in various government agencies' mission environments. An example of what is required is the Navy interaction with NIDDESC activity.
- Initiate exploratory development efforts to flesh out development concepts and demonstrate workable approaches to PDES level III. Pay particular attention to both scope and scale effects.
- Provide focus for the PDES voluntary effort via interactions with government contractors working on the PDES voluntary committees.
- Investigate economic incentives which must be established/ identified to encourage the rapid development and deployment of PDES technology. This may include efforts to help jell marketplace requirements for system vendors, create competitive advantage for manufacturers to use PDES, etc.
- Use the leverage and incentives to insure that database suppliers, CAD vendors and suppliers of products which support PDES are heavily involved as critical elements to PDES development. PDES will not be implemented without them.
- Continue the process of advocating change in government policies and procedures to exploit digital data technology.

- Investigate the advisability and feasibility of contracting changes to foster the PDES environment (e.g., the use of product data warranties where the contractor warrants the data to be reprocurement ready, etc). Such changes must be consistent with the fair and open competition initiatives within the government.
- Insure that government end users of data (particularly DOD) are involved in PDES logical model development and validation on a sustained basis. This implies providing travel funding and a willingness to incur the opportunity costs associated with active participation.
- Provide a continuing formal interface to PDES, Inc.

Agencies should:

- Seek out areas for interagency cooperation at the project level where synergistic potential exists to extend and improve portions of the PDES environment. DOD cooperation with DOE/NWC product definition exchange programs appears to be a particularly fruitful candidate for such cooperation (e.g., DOD could fund CALS related portions of DOE/NWC application protocol work, etc).
- Improve technology transfer with the PDES development community. Consider providing contract deliverables where appropriate, as well as direct feedback such as IPIM model sufficiency to RAMP objectives, etc. Specifically address any agency problems with international restrictions and the fact that PDES and STEP are considered synonymous.
- Insure that both on-going and planned PDES related projects are coordinated on a cross disciplinary basis. There is a particular need to initiate formal and continuing coordination between mechanically focused projects such as IDS and electronically focused projects such as EIS.
- Expand agency requirement generation and utilization of PDES in a sustained manner.

The PDES development community should:

- Individually develop and publish strategic development plans for their PDES activity. Coordinate them such that taken together they provide an architecture(s) for an "Advanced/fully realized" PDES implementation which is defined, commonly understood, and can be used to coordinate various development activities.

The IGES/PDES Volunteer Group should:

- Develop the product models and integrate them in a planned way. The planning should focus on meeting broad application needs and requirements.
- Scope PDES specification development in such a manner that uses high leverage data and supports the formation of concrete evidence that promised benefits and payoffs have been achieved or are achievable in a timely fashion, (e.g., a rational path for prototyping and proof of achievement).
- Ensure that the rationale for the "what and how chosen" aspects of model development are published. Specifically highlight targeted applications/implementations.
- Ensure the availability of a demonstration and testing methodology that can validate results and provide feedback for model development. The methodology must assure the investigation of the feasibility of the technical solutions on an impartial, results oriented basis. It should be targeted for eventual production use. The investigations and their outcome should be tied to the ratification process of the specification.
- Ensure that specific end user input is methodically sought out to provide realistic functionality to the PDES concept.
- Provide an education program that mitigates cultural transition and heightens management support. Education might include PDES user groups which provide for education and training for the effective use of the technology.

- Establish active liaison with the National Center for Manufacturing Sciences (NCMS) and similar organizations. The objectives of this liaison should be to provide the organizations with information and guidance concerning PDES projects and activities, and to establish linked strategies supporting the PDES goals.

PDES Inc. should:

- Make a concerted effort in their publicity releases, presentations at public forums, etc. to clarify roles, missions and interactions with the IGES/PDES Volunteer Group.
- Provide a continuing feedback path to the Volunteer Group on the adequacy of the integrated product model.

GLOSSARY

This glossary provides definitions for important terms and the meaning for those acronyms used in the main body of this report. A complete set of project related acronyms are contained in the first two pages of Appendix A.

Administrative Data — The set of data which define the part characteristics, materials, approvals and other miscellaneous information necessary to the production environment. Similar types of data exist in other environments as well (e.g., supply, maintenance, etc).

AMRF — Advanced Manufacturing Research Facility

ANSI — American National Standards Institute

Aperture Card — A computer data card having an opening or hole over which an image of a part drawing on microfilm is placed.

Application — A software program or procedure which creates and/or uses Product Definition Data.

Application Model — A data model which addresses the information requirements for a specific industry or vital business objective such as electrical design or structural analysis.

Application Subset — A defined set of specific entity types which are used to completely and unambiguously represent the information requirements for a particular application.

ASME — American Society of Mechanical Engineering

Attribute — A quality or characteristic element of an entity having a name and a value. An item of information about an entity. Properties of product data which describe the data objects.

Bit-Image Format Files -- A binary representation (usually raster form) of the pixels that compose the image file, which can be stored in digital format.

BREP — Boundary Representation

Business Data — Data that does not directly define or constrain the physical or functional characteristics of the product. Examples of business data are: costs, schedules, personnel requirements and facilities.

CAD — Computer Aided Design

CAE — Computer Aided Engineering

CALS — Computer-aided Acquisition and Logistics Support

CAM — Computer Aided Manufacturing

CIE — Computer Integrated Engineering

CIM — Computer Integrated Manufacturing

Computer Intelligible -- Describes information that is interpretable (or understood) by computer-based applications programs without the need for human interpretation or manipulation.

Computer Interpretable — See Computer Intelligible.

Conceptual Model -- An abstraction of the real world that conveys the concepts, meaning and semantics of information for an organization. It forms the basis for a dialogue between systems and users and is based on a common understanding of the information it represents.

Conceptual Schema — Formally specified global view that is processing independent, covering information requirements and formulation of independent information structures. A neutral view of data, usually represented in terms of entities and relations.

Constraint -- An assertion which specifies data meaning or semantics. A constraint may be expressed explicitly or contained implicitly.

CSG -- Constructive Solid Geometry

DARPA -- Defense Advanced Research Projects Agency

Data -- A representation of facts which can be used for processing or interpretation by a computer application program. Information input to, operated on, and generated by a computer system as it performs its task dictated by an application program.

Database -- A store of data which is used to define some part of the real world which is structured to satisfy a particular need.

DBMS -- Database Management System

DDT&E -- Design, Development, Test and Evaluation

DID -- Data Item Description

Digital Data -- Data represented in discrete discontinuous form as contrasted with analog data represented in continuous form. Any data represented in digital form.

Digital Information -- Any information represented in digital form.

Distributed Database -- An environment in which the data of interest is managed by a number of Database Management Systems residing on different computer systems.

DLA -- Defense Logistics Agency

DOC -- Department Of Commerce

DOD -- Department Of Defense

DOE -- Department Of Energy

DOEDEF — DOE Data Exchange Format

Drawing — A specific type of engineering data that discloses, either directly or by reference, by means of pictorial or textual presentations, or combinations of both, the physical and functional end-product requirements of an item.

DSREDS — Digital Storage and Retrieval Engineering Data System

EDCARS — Engineering Data Computer Aided Retrieval System

Engineering Data — Any data (government, contractor, or vendor) which contains authoritative engineering definition or guidance, on material, items, equipment system practices, methods, and processes relating to the design, manufacture, acquisition, test, inspection, or maintenance of items or services. It includes the following: drawings, associated lists, contractor or vendor specifications, standards, documents referenced on drawing lists, revision authorization documents, engineering change orders, government or industry associated specifications and standards, and other related documents.

Enterprise — May be a corporation, a unit or division of a corporation, government unit, or group of cooperating organizations, etc., which is the source or owner of information.

Entity — A collection of facts (attributes) about something of interest.

External Schema — External representation of data; the application program view of the data. It is used to ensure that the data is in the proper format and is readable by the application.

Feature — A special collection of geometric elements and functional characteristics that can be logically group together.

File -- A digital repository of organized information consisting of records, items or arrays, and data elements.

Format — A specific arrangement of data.

Geometry - The definition of three dimensional surfaces, curves, and points.

GMAP — Geometric Modeling Applications Interface Program

Graphics Data — Data used by a computer system to produce charts, graphs, drawings, pictures, or other graphic images on a graphics device and requiring a person to interpret the information content based on an ability to read the displayed information.

Heterogeneous Environment — A computing environment composed of different combinations of vendored computers (e.g. IBM, DEC, etc.), dissimilar operating systems (e.g. VMS, CMS, etc.), and multiple data management structures (e.g. ISAM, VSAM, CODASYL, Hierarchical, Network, Relational, Object) supported by different vendored Database Management Systems (e.g. Oracle, Ingres, VBase, etc).

IDS — Integrated Design Support System

IGES — Initial Graphics Exchange Specification

IGES/PDES Voluntary Organization — The organization, voluntary in its nature and open to any individuals, responsible for the creation of PDES. The organization consists of a series of committees dealing with the technical and managerial development of both IGES and PDES.

IISS — Integrated Information Support System

Implementation Level -- One of four different levels of PDES implementations consisting of File Exchange, Working Form Exchange, Shared Database, and Integrated Knowledge Base.

Information -- Composed of data items, the meanings (semantics) associated with the data items and the inter-relationships between the data items.

Information Model — An abstraction of the real world that conveys the concepts, meaning and semantics of information for an organization. It forms the basis for a dialogue between systems and users and is based on a common understanding of the information it represents. An information model is normally produced according to a set of procedures and is written using a particular modeling language.

Initial Graphics Exchange Specification (IGES) — A neutral file format for the representation and transfer of product definition data among CAD/CAM systems and application programs.

Integrated Conceptual Model -- A cohesive and consistent model which reflects a common understanding of information resources used within an enterprise. It is produced by merging together independently developed information models.

Integrated Database — A database which combines the data stores for two or more environments into a single unified data store in order to eliminate data redundancy.

IPDM — Integrated Product Data Model

IPIM — Integrated Product Information Model

ISO — International Organization for Standardization

Level 1 Implementation -- File Exchange - An implementation level involving the transfer of complete sets of product information as a passive file (typically a magnetic tape). Specialized translators embedded within applications are usually required to create and subsequently read the data.

Level 2 Implementation — Working Form Exchange - An implementation level in which applications use in-memory "working" versions of the data file. Generic parsers and query mechanisms may be shared among many applications.

Level 3 Implementation -- Database Exchange - An implementation level in which applications make requests for only the data they require to a centralized database containing the entire product data.

Level 4 Implementation — Knowledge Base Exchange - An implementation level in which a centralized or distributed database is used which contains an object-oriented form of the product data. The "knowledge base" capability stems from the capturing of constraints and behavior of the various entities and embedding this behavior in the data structured contained in the entities.

Logical Model — An abstraction of the real world that conveys the concepts, meaning and semantics of information for an organization. The logical model defines the contents and relations of a database.

NASA — National Aeronautics and Space Administration

NBS — National Bureau of Standards

NCMS — National Center for Manufacturing Sciences

Neutral Form — The non-system specific (neutral) representation of the product definition data which is used in performing file exchange.

NIDDESC — Navy/Industry Digital Data Exchange Standards Committee

NIST — National Institute of Standards and Technology

NWC — Nuclear Weapons Complex

Object-Oriented Database — An environment in which the management of objects is accomplished where an object can be described as a collection of functions (programs) and data. Objects are typed according to classes and sub-classes giving them the ability to inherit the characteristics of their 'parent' type. An object-oriented database management system provides software support to directly manage these objects by supporting all of the data, relationships, and behavior of the objects within the DBMS.

OSD -- Office of the Secretary of Defense

PDES — Product Data Exchange Specification

PDES Environment — The convergence of several activities consisting of a research base of implementing technologies, the development of a specification for product data representation in digital form, implementations in software, validity checking and testing methodology, guidelines for usage in identified applications areas, and production use.

PDES, Inc. — A corporation formed to pursue a major industrial effort intended for acceleration of PDES development and implementation.

Physical Implementation — The actual physical storage of the information. This includes the format (e.g. ASCII) and media (e.g. tape) on which the information is stored.

Physical Schema — Internal representation of data; the computer view that includes stored record format and physical ordering of stored records.

Process Data — Those data which explicitly are used define or are used to directly control the manufacturing processes used in the production of the product.

Product Data — All data elements necessary to define the geometry, the function, and the behavior of a piece part or an assembly of parts over its entire life-span. The term includes all product definition data elements as well as additional logistics elements such as those for reliability and maintainability.

Product Data Exchange Specification/Standard for the Exchange of Product Data (PDES/STEP) -- Standards (under development) for communicating a complete product model with sufficient information content so as to be interpretable directly by advanced CAD/CAM applications such as generative process planning, CAD directed inspection, and automatic generation and verification of NC Cutter path data. PDES is being developed as a national standard and STEP is being developed as the international counterpart under the sponsorship of ISO TC184/SC4.

Product Definition Data -- Denotes the totality of data elements required to completely define a product. Product definition data includes geometry, topology, relationship, tolerances, attributes, and features necessary to completely define a component part or an assembly of parts for the purpose of design, analysis, manufacture, test, and inspection. Those data explicitly representing all required concepts, attributes, and relationships normally communicated from Design throughout Manufacturing. The data include both shape and nonshape information required to fully represent a component or assembly so that it can be analyzed, manufactured, and inspected. They enable downstream applications, but do not include process instructions. These data are not always finalized at the design release; the manufacturing process can also add to the product model or generate derived manufacturing product models.

Product Life Cycle -- The distinct phases into which every system may be divided such as design, analysis, manufacturing, inspection, and product and maintenance/logistics support.

Product Model -- A representation of a product. In this report such a model is digital and computer-based.

R&D -- Research and Development

Relationship -- A logical association between entities.

Schema -- Formal definition of information structure. See Conceptual Schema, External Schema, Physical Schema.

Shape Data -- The physical geometry of a mechanical part. Those data including the geometric, topological description of a product along with the associated dimensional tolerances and feature descriptions.

Shared Database -- A database which supports the data store needs of two or more computer-related application environments.

Shared Database Implementation -- See Level 3 Implementation.

SSP -- Space Station Program

STEP -- Standard for the Exchange of Product Model Data

Technical Data Package -- A document which contains the collection of all of the technical information required to manufacture the product with which the package is associated. Technical Data Packages are typically used by logistics support functions in the procurement of spare or replacement parts.

Testing Draft -- A version of the PDES Integrated Product Information Model (IPIM) released quarterly for application testing.

TMIS -- Technical and Management Information System

Tolerance -- The total amount by which something may vary. For mechanical product definition, tolerances can be shape tolerances, weight tolerances, finish tolerances and so on.

Topical Data -- Those data dealing with an aspect of the product definition data from within a particular topical area (e.g. geometry, topology, tolerances).

Topical Model -- A data model which incorporates the requirements of many users into a data model of limited scope. The scope defines the topic of the data model (e.g., geometry data model).

Working Form -- A memory resident form of a model that supports rapid access to entities via a set of access routines.

APPENDIX A

PDES RELATED PROJECTS

This appendix contains synopses for the twenty-seven (27) projects reviewed by the task group. They are presented alphabetically by title as follows:

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Apparel Product Definition Exchange Standard (APDES)	A-3
Automated Manufacturing Research Facility (AMRF)	A-7
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CALS Test Network	A-17
Concurrent Product and Process Design (First Cut)	A-21
DARPA Initiative in Concurrent Engineering (DICE)	A-25
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Design Knowledge Capture (DKC) for Space Station	A-33
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Product Definition Initiative (PDI)..... A-83
Rapid Acquisition of Manufactured Parts (RAMP)..... A-85
Seawolf Advanced Submarine Acquisition Program..... A-89
Technical Management Information System (TMIS)..... A-93
University of Utah ALPHA-1 Solid Modeling System..... A-97
VHSIC Hardware Description Language (VHDL)..... A-101

TITLE: Apparel Product Definition Exchange Standard (APDES)

RESPONSIBLE ORGANIZATION: DLA - Manufacturing Engineering/Research Office (DME/RO)

KEY GOVERNMENT CONTACT: Mr. Don O'Brien (202) 274-6445

CONTRACTOR: National Institute of Standards and Technology (NIST)

SHORT OBJECTIVE: Develop file specifications for apparel geometric data and a plan for a full apparel PDES that includes all attributes required to design and manufacture a garment.

PUBLIC RELEASE INFO AVAILABLE: Not at this time

RELATED PROJECTS (WHICH ONES & HOW): Military Sewn Products Automation is the umbrella project for APDES.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes - preliminary plan calls for neutral file format and full implementation plan to be developed and delivered in 18 months.

Major Milestones: The following are to be developed and/or delivered within 18 months. Neutral file specification; demonstration of prototype APDES data transfer; APDES workshop proceedings; plan for APDES.

Cognizant of PDES Development Schedule: Yes, as NIST personnel are developers.

PDES Impact Potential:

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Project cost by FY:

Prior	88	89	90	91	92	outyear
		450K	0	0	0	0 (actually spans 18 months)

Total M/Y of effort for Government (Include MTS): approximately 3 my from NIST

Total M/Y of effort for Contract: N/A - volunteer industry time will follow.

INFORMATION SCOPE:

Class of Topical Data: Geometric definition of apparel patterns.

Class of Product: Potential to relate to other pattern activities.

Product Life Cycle Target: APDES is aimed at design and manufacturing.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File: Yes

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: A file specification will be developed and exchange demonstrated.

Required Resources:

Demonstration Only, None Required: Yes

Defined:

Planned:

Programmed:

In Place:

Comments:

Required Procedures: N/A

Defined:

Developed:

Coordinated:

In Place:

Comments:

Testing:

Scenario(s) Defined: Yes

Test Plan Developed:

Comments: For demonstration only of file transfer.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes, as NIST is the contractor.

Which Group & Subcommittee: Virtually all.

Government Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Provide Briefings to PDES Community: Not yet

Provide Results to PDES Community: From NIST work

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: Yes

Receive Results from PDES Community: Yes

Receive Project Deliverables from PDES Community: Yes

Comments: *Interface with educational institutions, industry groups* and government organizations is actively pursued as part of the program.

TITLE: Automated Manufacturing Research Facility (AMRF)

RESPONSIBLE ORGANIZATION: Department of Commerce, National Institute of Standards and Technology (NIST), Center for Manufacturing Engineering

KEY GOVERNMENT CONTACT: Dr. Dennis Swyt, (301) 975-3401

CONTRACTOR: N/A

SHORT OBJECTIVE: The objective of the project is to build and maintain a manufacturing testbed facility where research can be performed on emerging standards.

PUBLIC RELEASE INFO AVAILABLE: Yes, booklet, briefing, etc.

RELATED PROJECTS (WHICH ONES & HOW): Although not specifically related to other projects, the AMRF is a critical element of CALS development and validation.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: N/A

Major Milestones: (1) Implement a manufacturing data preparation system, October 1988. (2) Implement a PDES testbed facility, October 1989. (3) Demonstrate a PDES Level 3 implementation, October 1990. (4) Initiate a design for quality manufacturing project, October 1991.

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Direct as a potential testbed.

Specifics (version 1.0, 2.0, 3.0, later, etc.): 1.0 and out.

Project cost by FY: (AMRF Total Not Just PDES Potential) ($M)

Prior	88	89	90	91	92	outyear
40	10	----------				Level

Total M/Y of effort for Government (Include MTS): 100 my/y

Total M/Y of effort for Contract: Research Associates 3 my/y

INFORMATION SCOPE:

Class of Topical Data: A variety of topical data will be utilized including shape size, BOM, process planning, functional characteristics such as tolerances and physical characteristics.

Class of Product: Mechanical parts which fit within a 1-foot cubed volume. No assembly.

Product Life Cycle Target: Design, analysis, and manufacturing (includes material ordering, inspection, machining, deburring, etc.). No support.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange:

Shared Database: Target

Integrated Knowledge Base:

Specific CAD/CAM Systems: ComputerVision

Specific Geo Modelers: PADL II, BRL, ROMULUS, ALPHA ONE

Specific DB Enviro: RIM, INGRES (MDOS)

Specific DB Modeling Tool: PC-IAST, JANUS/LEVERAGE, NEW CASE TOOL

Specific Computers: 11/785, Sun Systems, PCs, Silicon Graphics, Symbolics, etc.

Level of Documentation: Complete design specification for system.

Comments:

Required Resources:

Demonstration Only, None Required: N/A

Defined: N/A

Planned: N/A

Programmed: N/A

In Place: N/A

Comments: The AMRF is a testbed. Resources are in place.

Required Procedures:

Defined: N/A

Developed: N/A

Coordinated: N/A

In Place: N/A

Comments: A testbed, not a production implementation.

Testing:

Scenario(s) Defined: Various

Test Plan Developed:

Comments: The testbed gives a major demonstration once a year targeted around selected scenarios.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: N/A

Which Group & Subcommittee: N/A

Government Personnel Actively Participate in PDES Activities: Yes, virtually everywhere.

Which Group & Subcommittee: Throughout, from the head of the IGES/PDES national effort to assorted subcommittees.

Provide Briefings to PDES Community: Yes

Provide Results to PDES Community: Yes

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: Yes

Receive Results from PDES Community: Yes

Receive Project Deliverables from PDES Community: Yes

Comments:

TITLE: Computer Aided Acquisition and Logistics (CALS) Support

RESPONSIBLE ORGANIZATION: PM-CALS (OSD)

KEY GOVERNMENT CONTACT: Mr. Dave Ruppe, AES-PES-CA, Fort Monmouth, New Jersey 07703, (201) 544-3170

CONTRACTOR: N/A

SHORT OBJECTIVE: This project will build the Army CALS infrastructure. It is acquisition sensitive at this time. The RFP will be released soon. This write-up will be finished once the RFP is available.

PUBLIC RELEASE INFO AVAILABLE:

RELATED PROJECTS (WHICH ONES & HOW):

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published:

Major Milestones:

Cognizant of PDES Development Schedule:

PDES Impact Potential:

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Project cost by FY: (subset of total) $M

Prior	88	89	90	91	92	outyear

Total M/Y of effort for Government (Include MTS):

Total M/Y of effort for Contract:

INFORMATION SCOPE:

Class of Topical Data:

Class of Product:

Product Life Cycle Target:

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments:

Required Resources:

Demonstration Only, None Required:

Defined:

Planned:

Programmed:

In Place:

Comments:

Required Procedures:

Defined:

Developed:

Coordinated:

In Place:

Comments:

Testing:

Scenario(s) Defined:

Test Plan Developed:

Comments:

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities:

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities:

Which Group & Subcommittee:

Provide Briefings to PDES Community:

Provide Results to PDES Community:

Provide Contract Deliverables to PDES Community:

Receive Briefings from PDES Community:

Receive Results from PDES Community:

Receive Project Deliverables from PDES Community:

Comments:

TITLE: CALS Reprocurement Initiative

RESPONSIBLE ORGANIZATION: AFSC/ASD/WRDC/MT

KEY GOVERNMENT CONTACT: Mr. Charles Gillman, (513) 255-7371

CONTRACTOR: Not yet on contract.

SHORT OBJECTIVE: The objective of this effort is to succinctly define the technical data content of select Air Force spare parts reprocurement bid packages and to build and demonstrate a prototype computer assisted system that supports the collection and organization of these data.

PUBLIC RELEASE INFO AVAILABLE: No

RELATED PROJECTS (WHICH ONES & HOW): Uses "PDES-like" data as a potential hedge against PDES not being developed enough to utilize.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones: Milestone dates are based on a tentative contract award date of September 1988.

Problem Definition	Sep 88 - Feb 89
Generation of Near Term System Designs	Mar 89 - Nov 89
Build and Demonstrate Near Term System	Dec 89 - Feb 91
Generate Plans for Advanced Technology System	Dec 89 - Aug 90
Build Advanced Technology System	Sep 90 - Sep 91

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, details are acquisition dependent.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 3.0 and out.

Project cost by FY:

Prior	88	89	90	91	92	outyear
	.002	1.5	3.0	2.6		

Total M/Y of effort for Government (Include MTS): 1.5 my total.

Total M/Y of effort for Contract: 22 my

INFORMATION SCOPE:

Class of Topical Data: "All" focus on technical data required for manufacture.

Class of Product: Mechanical, ideas on assembly unclear at this time but not counting on it.

Product Life Cycle Target: Support via spare reprocurement.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File: Yes

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: Too early in cycle for detail

Required Resources:

Demonstration Only, None Required: Yes

Defined: N/A

Planned: N/A

Programmed: N/A

In Place: N/A

Comments: Logistics Command will follow closely even though the project is demonstration only.

Required Procedures:

Defined: N/A

Developed: N/A

Coordinated: N/A

In Place: N/A

Comments: Too early in cycle for detail. May lead to procedures.

Testing:

Scenario(s) Defined: No

Test Plan Developed: No

Comments: Test plan will be developed. Want to drive toward use by ALC personnel during test activities.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: N/A

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: General session attendance.

Provide Briefings to PDES Community: No

Provide Results to PDES Community: N/A

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: Yes, via participation.

Receive Results from PDES Community: Yes, via participation.

Receive Project Deliverables from PDES Community: No

Comments:

TITLE: CALS Test Network

RESPONSIBLE ORGANIZATION: HQ AFLC/SCTA

KEY GOVERNMENT CONTACT: Mr. Melvin Lammers, (513) 257-3085

CONTRACTOR: Lawrence Livermore National Labs (LLNL) is technical agent.

SHORT OBJECTIVE: Demonstrate the interchange of digital technical information between industry and DOD using the CALS standard MIL-STD-1840A covering: (1) the Initial Graphics Exchange Standard (IGES), (2) the Standard Generalized Markup Language (SGML), (3) RASTER, and (4) Computer Graphics Metafile (CGM).

PUBLIC RELEASE INFO AVAILABLE: Not at this time.

RELATED PROJECTS (WHICH ONES & HOW): Being pursued under CALS.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones: Initially a two-year effort (started January 1988) calling for: (1) network definition, (2) MOA development with participants, (3) development and installation of test platforms, (4) identification and assignment of test tasks, (5) detailed test design, (6) test conduct, and (7) publishing of results.

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, via lessons learned and testing potential if augmented for PDES.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 1.0 and out.

Project cost by FY: (subset of total) $M

Prior	88	89	90	91	92	outyear
	1.8	2.0				

Total M/Y of effort for Government (Include MTS): 2.0 in 1988 and 4.0 in 1989.

Total M/Y of effort for Contract: 7 my/y

INFORMATION SCOPE:

Class of Topical Data: Digitial technical data - test and graphics. The emphasis is on interchange.

Class of Product: Not focused at a particular product class.

Product Life Cycle Target: No LSA or LSAR data.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File: Yes

Active Exchange: Yes

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems: Eventually all.

Specific Geo Modelers:

Specific DB Enviro: Non-specified in particular.

Specific DB Modeling Tool: Focus on transmission.

Specific Computers: Initially VAX, Micro VAX, Sun, and Apple Macintosh II.

Level of Documentation:

Comments: Focus is on the installed (plus near-term achievable) base.

Required Resources:

Demonstration Only, None Required:

Defined: Yes

Planned: Yes

Programmed: Yes

In Place: No

Comments: This is a test network. Required resources are programmed by DOD.

Required Procedures:

Defined: N/A

Developed: N/A

Coordinated: N/A

In Place: N/A

Comments: Will help in defining specific application procedures to be used by operational elements.

Testing:

Scenario(s) Defined:

Test Plan Developed:

Comments: Will have a series of tests. A strategic test plan has been developed and is presently in coordination.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee:

Provide Briefings to PDES Community: Not yet.

Provide Results to PDES Community: Not yet.

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: Yes

Receive Results from PDES Community: Yes, via LLNL.

Receive Project Deliverables from PDES Community: No

Comments:

TITLE: Concurrent Product and Process Design (First Cut)

RESPONSIBLE ORGANIZATION: DARPA/ISTO

KEY GOVERNMENT CONTACT: Mr. Pete Brown, National Institute of Standards and Technology (NIST), (301) 975-3513

CONTRACTOR: Dr. Mark R. Cutkosky, Principal Investigator, Assistant Professor Stanford University, Mechanical Engineering Department, Palo Alto, California 94305

SHORT OBJECTIVE: First Cut has been designed to bridge the gap between design and manufacturing. The goal is to improve quality and to reduce time to market. One way to bridge the gap is to simultaneously design the product and the process to produce it. The system has been developed to allow rapid prototyping of mechanical components. The designer works in a manufacturing mode, that is applying operations to transform geometry. Once the geometry has been specified by a sequence of manufacturing operations (a process plan) the execution of the plan is run and monitored.

PUBLIC RELEASE INFO AVAILABLE: Several papers have been published.

RELATED PROJECTS (WHICH ONES & HOW): DARPA ALPHA-1, Cornell and NIST. Contact Mr. William E. Isler at DARPA, (202) 694-4001, ARPANET: isler@vax.darpa.mil. These systems will be used to investigate an integrated product life-cycle design system.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: No

Major Milestones: The first implementation has been completed. Some manufacturing knowledge of machining has been incorporated. An interface to the ALPHA-1 solid modeler has been developed as well as interfaces to several machine tools. The researchers are planning some major revisions with the new funding.

Cognizant of PDES Development Schedule: Unknown

PDES Impact Potential:

Specifics (Version 1.0, 2.0, 3.0, later, etc.): Much of the work will support the general requirements found in PDES Version 1.0. It could potentially fit into several of the levels. Many of the issues deal with support of integration of design and manufacturing so should be considered looking towards future versions. In terms of the appropriate level this system deals with the shared database and integrated knowledge base levels. DARPA desires that this research project and others related to it should have a close working relationship with the PDES effort.

Project cost by FY: (subset of total) $M

Prior	88	89	90	91	92	outyear

Total M/Y of effort for Government (Include MTS):

Total M/Y of effort for Contract:

INFORMATION SCOPE: First Cut is intended to help bridge the gap between design and manufacture. The implementation allows for several areas of the life-cycle (such as serviceability, product production and engineering analysis) to also post constraints.

Class of Topical Data:

Class of Product: First Cut is a tool for rapid prototyping of mechanical components and electro-mechanical assemblies. It is a research tool.

Product Life Cycle Target: First Cut deals primarily with detailed design and process planning. It has the capability to cover other apsects of the product life cycle as mentioned above.

IMPLEMENTATION:

Environment Target: Many of the concepts are targeted towards the shared database or integrated knowledge base.

Nonspecific:

Passive File:

Active Exchange:

Shared Database:

Integrated Knowledge Base: With the use of the Hyperclass systems by First Cut and potentially NIST and Cornell this level of PDES could be supported.

Specific CAD/CAM Systems:

Specific Geo Modelers: ALPHA-1 is a solid modeling system that supports the generation of geometric primitives such as lines, arcs, etc., and surfaces and solids. It is a spline-based modeler.

Specific DB Enviro: First Cut uses the Hyperclass system which is an object-oriented environment.

Specific DB Modeling Tool:

Specific Computers: First Cut runs on a Sun Microsystems computer, with the Sun Common Lisp environment.

Level of Documentation: None yet received.

Comments:

Required Resources:

Demonstration Only, None Required: Yes

Defined:

Planned:

Programmed:

In Place:

Comments: The system requires a workstation with sufficient memory (approximately 12-16 megabytes) and disk space on the order of 50 + megabytes.

Required Procedures:

Defined: N/A

Developed: N/A

Coordinated: N/A

In Place: N/A

Comments: The First Cut system is a research project on concurrent design. It will have impact on what kinds of information needs to be exchanged between design and manufacturing. The results will most likely help in moving future versions of PDES towards complete product life-cycle definition.

Testing:

Scenario(s) Defined: No

Test Plan Developed: No

Comments:

TECHNOLOGY TRANSFER: DARPA has established a NIST University group to investigate research topics in the area of design for manufacturing and product life-cycle definition. NIST is the site of the voluntary PDES work, it is involved with industry consortiums, and will head a OSD national PDES testbed effort. Several of the University projects are part of the NSF Engineering Research Centers as well as having numerous industrial partners.

Contractor Personnel Actively Participate in PDES Activities:

Which Group & Subcommittee: No

Government Personnel Actively Participate in PDES Activities: Yes, through NIST.

Which Group & Subcommittee:

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments:

TITLE: DARPA Initiative in Concurrent Engineering (DICE)

RESPONSIBLE ORGANIZATION: DARPA/DMO

KEY GOVERNMENT CONTACT: Dr. Phillip A. Parrish (202) 697-8499

CONTRACTOR: General Electric Schenectady NY is prime with various universities as subcontractors.

SHORT OBJECTIVE: The objective of the DICE program is to create a computer-assisted, integrated design environment that synchronizes, schedules and refines information flow between disciplines in the product development cycle and fuses all constraints, including life-cycle requirements, into the design generation. The program will demonstrate and transfer concurrent engineering technology to industry.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): None

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones: Establish a center for concurrent engineering research. Develop a candidate network based, distributed information management architecture. Develop and apply advanced design tools. Timing of these milestones is still being worked.

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Appears to have Level 4 potential.

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Project cost by FY:

Prior	88	89	90	91	92	outyear
	4M	9M				

Total M/Y of effort for Government (Include MTS): 1 MY/year

Total M/Y of effort for Contract: TBD

INFORMATION SCOPE:

Class of Topical Data: Not specific.

Class of Product: Both mechanical and electrical.

Product Life Cycle Target: DICE is aimed at the design environment however it attempts to insure consideration of the full spectrum of life cycle needs.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange:

Shared Database: Yes

Integrated Knowledge Base: Yes, target.

Specific CAD/CAM Systems: Proprietary at this time.

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: Distributed information management is key to program success.

Required Resources:

Demonstration Only, None Required: Yes

Defined:

Planned:

Programmed:

In Place:

Comments:

Required Procedures: N/A - demonstration

Defined:

Developed:

Coordinated:

In Place:

Comments:

Testing: N/A - demonstration

Scenario(s) Defined:

Test Plan Developed:

Comments:

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments:

TITLE: Department of Energy Data Exchange Format (DOEDEF)

RESPONSIBLE ORGANIZATION: Sandia National Laboratories, Albuquerque, New Mexico.

KEY GOVERNMENT CONTACT: Mr. Don W. Doak, Dept. 2810, Computer Aided Design and Integration Department, Sandia National Laboratories.

CONTRACTOR: Developed internally by DOE Nuclear Weapons Complex (NWC).

SHORT OBJECTIVE: Standardized external representation of mechanical design/drafting data to enable archive of this data, exchange between dissimilar CAD systems, and use in other application areas.

PUBLIC RELEASE INFO AVAILABLE: DOEDEF format specification for mechanical design/drafting. Certain software to be put into public domain very shortly. Presentation materials (e.g., to IGES Quarterly meeting).

RELATED PROJECTS (WHICH ONES & HOW): IGES - The current DOEDEF specification is a restriction of the IGES specification for mechanical design/drafting purposes. Future DOEDEF specifications will evolve toward an application protocol format as this is understood in IGES. PDIDOE Product Definition Initiative (PDI) will concentrate on PDES-type product models. DOEDEF is concentrating on current CAD/CAM systems (drawings and wireframe models), but will draw on the results of PDI drafting model work.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Internally only.

Major Milestones: (1) Revised - DOEDEF Specification for Mechanical Design/Drafting, January 1987. (2) Production software tools for flavoring IGES data, August 1987. (3) DOE/NWC sites have production capability for visually equivalent exchange of mechanical part drawings, and for exchange of 3D wireframe models, October 1988. (4) DOEDEF specification augmented for increased functionality and corresponding production capability, middle to late 1989.

Cognizant of PDES Development Schedule: Yes, however there is no direct influence.

PDES Impact Potential: Yes, works both infrastructure needs and technology voids (e.g., application protocols).

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 1.0 and out.

Project cost by FY: (subset of total) $M

Prior	88	89	90	91	92	outyear

Total M/Y of effort for Government (Include MTS): 84-87/31, 7 (in both 1988 and 1989).

Total M/Y of effort for Contract:

INFORMATION SCOPE:

Class of Topical Data: Information relates to 3D wireframe models and mechanical part drawings.

Class of Product: The class of product is mechanical parts.

Product Life Cycle Target: Design phase.

IMPLEMENTATION:

Environment Target:

Nonspecific: Passive file/working form.

Passive File:

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems: Anvil-4000, Anvil-5000, Applicon Image/880, Applicon BRAVO, Calma DDM, ComputerVision, CDC ICEM DDN.

Specific Geo Modelers:

Specific DB Enviro: Boeing Computer Services RIM relational DBMS.

Specific DB Modeling Tool:

Specific Computers: VAX family.

Level of Documentation: Complete.

Comments:

Required Resources:

Demonstration Only, None Required: N/A

Defined: Yes

Planned: Yes

Programmed: Yes

In Place: Yes

Comments:

Required Procedures:

Defined: Yes

Developed: Yes

Coordinated: Yes

In Place: Yes

Comments:

Testing:

Scenario(s) Defined: Yes

Test Plan Developed: Yes

Comments: Test plan developed. Testing in progress. Capabilities demonstrated at some DOE/NWC sites. See major milestones.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities:

Which Group & Subcommittee: N/A

Government Personnel Actively Participate in PDES Activities: Yes, but IGES related.

Which Group & Subcommittee:

Provide Briefings to PDES Community: See comments.

Provide Results to PDES Community: See comments.

Provide Contract Deliverables to PDES Community: N/A

Receive Briefings from PDES Community:

Receive Results from PDES Community:

Receive Project Deliverables from PDES Community:

Comments: Provide briefings to IGES community. Rely on IGES community to complete the connection to PDES. Place software tools in public domain.

TITLE: Design Knowledge Capture (DKC) for Space Station

RESPONSIBLE ORGANIZATION: NASA Space Station Program (SSP) Office

KEY GOVERNMENT CONTACT: Mr. Ken Crouse, (713) 483-2040

CONTRACTOR: Grumman Aerospace plus SSP work package contractors.

SHORT OBJECTIVE: Capture the design and rationale of the space station in computer interpretable form to the maximum extent possible.

PUBLIC RELEASE INFO AVAILABLE: No

RELATED PROJECTS (WHICH ONES & HOW): DKC is contingent upon the TMIS project and general progress related to engineering databases.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes, on a work package basis.

Major Milestones: (1) Manual collection of design rationale. Design and development of design databases, 1989. (2) Electronic capture and development of user applications plus development of functional and behavioral models, 1990. (3) Capture at function and behavior levels based upon models, 1991.

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, design intent related.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 3.0 and out.

Project cost by FY: Rough estimate available only at this time. For work package 2 it is less than $1 million per year. On a total basis the support is somewhere between $0 and $2 million per year over a 10 year period.

Prior	88	89	90	91	92	outyear

Total M/Y of effort for Government (Include MTS):

Total M/Y of effort for Contract:

INFORMATION SCOPE:

Class of Topical Data: The level of detail is a function of criticality of the particular piece of equipment being designed. Eventually desire functional and behavioral descriptions.

Class of Product: Will eventually look at both mechanical and electrical classes. Original focus is with electrical.

Product Life Cycle Target: Design is what is being captured, however, NASA desires to support the space station over its lifetime of 30 years. This implies an ongoing capture of changes (test, maintenance, etc.) on a continuing basis.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange:

Shared Database: Start

Integrated Knowledge Base: Eventual goal for downstream application.

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: TMIS provides the DKC environment. Contractors will be able to use their own hardware and software but must store in the TMIS environment.

Required Resources:

Demonstration Only, None Required: Yes

Defined:

Planned:

Programmed:

In Place:

Comments: Resources are per TMIS provisions.

Required Procedures:

Defined:

Developed:

Coordinated:

In Place:

Comments: General guidelines only have been provided at this time (process requirements documents).

Testing:

Scenario(s) Defined: No

Test Plan Developed: No

Comments: Process requirements documentation includes testing information. General verification suggestions are provided including use of an auditing board. At this time only procedural information has been provided for verification.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes, on a company basis (e.g., McDonnell Douglas for work package 2).

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: Informally

Which Group & Subcommittee:

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments: No feed forward plans have been formulated yet. An informal intent exists to communicate and share information with the PDES community.

TITLE: Digital Product Models

RESPONSIBLE ORGANIZATION: AFSC/ASD/WRDC/MT

KEY GOVERNMENT CONTACT: Mr. Alan Winn, (513) 255-7371

CONTRACTOR: There are two contract teams, one led by Lockheed and one by Northrop. Members are Boeing, General Dynamics and McDonnell Douglas.

SHORT OBJECTIVE: The Digital Product Models project is potentially the first major application of the technology established by the product definition data interface project and the national standard that is evolving from the Product Data Exchange Specification (PDES) committee efforts. The intent of this project is to demonstrate the potential for use of digital product models in place of the paper engineering drawings that are currently required for delivery of systems product data.

PUBLIC RELEASE INFO AVAILABLE: No

RELATED PROJECTS (WHICH ONES & HOW): GMAP and PDDI are precursors. The project thrust is to use PDES in the real world to replace level III drawings.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones:

Evaluate PDES and Select Parts	Mar 88
Construct Model and Database	Apr 89
Evaluate Suitability	Dec 89
Recommend AF System and Cost/Benefit Analysis	Jun 90
Final Report	Nov 90
FSD Award	Dec 90

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, defines requirements.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 3.0 and out.

Project cost by FY: ($M)

Prior	88	89	90	91	92	outyear
	4.0	2.0	2.0			

Total M/Y of effort for Government (Include MTS): 1.5

Total M/Y of effort for Contract: 50

INFORMATION SCOPE:

Class of Topical Data: This class of topical data is related to shape and size. Blueprint notes on material are available.

Class of Product: Mechanical parts, (no assembly targeted).

Product Life Cycle Target: The predominant focus is on production.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File: Yes

Active Exchange: Yes

Shared Database: Unknown

Integrated Knowledge Base: No

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: Not yet on contract but will step towards shared database. Environment is a function of contractor.

Required Resources:

Demonstration Only, None Required: Yes

Defined: N/A

Planned: N/A

Programmed: N/A

In Place: N/A

Comments: Project feeds full scale development. If project is successful, it will be implemented. This may occur through contractor channels.

Required Procedures:

Defined:

Developed:

Coordinated:

In Place:

Comments: No specific application has been selected (in process).

Testing:

Scenario(s) Defined:

Test Plan Developed:

Comments: Test plan and specific scenarios are contractually required and will be developed.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: Volunteer and cooperative.

Government Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee:

Provide Briefings to PDES Community: Planned

Provide Results to PDES Community: Planned

Provide Contract Deliverables to PDES Community: Planned

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: Through participation.

Comments: There will be an industry review board. Plans are to utilize the GMAP board.

TITLE: Digital Storage and Retrieval Engineering Data System (DSREDS)

RESPONSIBLE ORGANIZATION: ISC - MICOM DSREDS Program Office, Redstone Arsenal, Alabama 35898

KEY GOVERNMENT CONTACT: Mr. Dave L. Stanbrough, (205) 876-8251

CONTRACTOR: AT&T, Patriots Plaza 600 Columbia Turnpike, Morristown, New Jersey 07960

SHORT OBJECTIVE: The objective is to scan, digitize, and store engineering data and specifications on optical disk. This will be used by technical data repository personnel, as well as engineering personnel, for the viewing and revising of engineering data on graphics display terminals. Producing bid sets of aperture cards for procurement of Army material is also an objective.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): Related projects included TD/CMS, CALS, MEDALS and MASTER.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes, (part of economic analysis).

Major Milestones: DSREDS sites at MICOM and CECOM has been installed and are loading data. MICOM has 534,000 loaded (aperture cards) and CECOM has 15,000 loaded.

Cognizant of PDES Development Schedule: No

PDES Impact Potential: No, direct impact beyond infrastructure.

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Approximate Project cost by FY: ($M) Acquisition, management, maintenance and operation only.

	Prior	88	89	90	91	92	outyear	(thru 1998)
Army only	1	2	9	10	12	90		
	60							

Total M/Y of effort for Government (Include MTS): Approximately 40 my's to date (Army only).

Total M/Y of effort for Contract: Approximately 300 my's to date (contractor only).

INFORMATION SCOPE:

Class of Topical Data: There are 28 CDRLs including a functional description, system/subsystem specifications, database specifications, program Specifications.

Class of Product: The class deals with both mechanical and electrical systems using optical, laser and ADP technology.

Product Life Cycle Target: Support; system "life" (for DSREDS) is designed to be 8 years after the warranty period (1st year of production) expires.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File: Yes, raster data.

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers: N/A

Specific DB Enviro: IBM

Specific DB Modeling Tool: N/A

Specific Computers: IPL 4460

Level of Documentation: CDRLs, user manual, program specification, operator manual, test plan, functional description, OEM documentation.

Comments: System is using standard IGES, MIL-D-28000 and DSREDS formats.

Required Resources:

Demonstration Only, None Required:

Defined: Yes

Planned: Yes

Programmed: Yes

In Place: Yes

Comments:

Required Procedures:

Defined: Yes

Developed: Yes

Coordinated: Yes

In Place: Partially, will be within the year.

Comments:

Testing:

Scenario(s) Defined: In formal test plan (CDRL A00N).

Test Plan Developed: Yes

Comments:

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: N/A

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: Some, but very limited.

Which Group & Subcommittee: CALS meetings and local R&D community.

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments:

TITLE: Engineering Information System (EIS)

RESPONSIBLE ORGANIZATION: AFSC/ASD/AFWAL/AADE

KEY GOVERNMENT CONTACT: Lt. Nick Naclerio, (513) 255-4448

CONTRACTOR: Prime - Honeywell, Subs - Computer Corp. of America (CCA), TRW, McDonnell Douglas Astronautics Co., CAD Language Systems Inc. (CLSI), and Arizona State University.

SHORT OBJECTIVE: Develop and demonstrate a set of standards which will facilitate the cost effective integration of new and existing CAE tools and DBMS's. This will be done in such a way as to encourage uniformity of user interfaces, portability of tools, exchange and reuse of design information, and extensibility. In addition, it will make new functionality possible and lower tool development costs. One of the basic EIS philosophies is that information sharing can only take place if tools are working under a common information model. EIS will develop an object oriented modeling method and language to support MIS. In addition, an information model will be developed for those objects which would be common to any EIS (things like files, events, system resources, etc). To support the electronic CAD prototype an information model will be developed which includes, as a minimum, all of the information in VHSIC Hardware Description Language (VHDL) and two views of Electronic Data Interchange Format (EDIF) (schematic and PCB0). This model is being developed in coordination with IEEE standards groups. That portion of the model which can be represented in IDEF1X will be represented as such, to support the PDES modeling effort in that area.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): VHDL is a precursor.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones:

	PDR	CDR	FDR
EIS Spec and Candidate Standards	Nov 87	Jun 88	Dec 88
EIS Prototype	May 89	Sep 89	Dec 89
Demonstration - May 90, Industry Coordination Meetings	Jan 88	Sep 88	TBA

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, design focus.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 3.0 and out

Project cost by FY: ($M)

Prior	88	89	90	91	92	outyear
1.2	6.5	6.7	2.8			

Total M/Y of effort for Government (Include MTS): 10

Total M/Y of effort for Contract: 75

INFORMATION SCOPE:

Class of Topical Data: EIS can be used to manage any type of data. As part of the program an information model is being developed for electronic CAD and EIS related objects (files, tools, events, configurations, etc.).

Class of Product: EIS will include an object oriented modeling method and language which can be applied to any domain. The product information modeled in prototype demonstration will pertain to IC and PCB designs.

Product Life Cycle Target: EIS can support any portion of the product life cyle. The prototype will demonstrate design.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange:

Shared Database: Yes, EIS will function in a distributed environment and support rule processing.

Integrated Knowledge Base: Yes

Specific CAD/CAM Systems: Mentar, Redae

Specific Geo Modelers: No

Specific DB Enviro: SQL and others.

Specific DB Modeling Tool: OODL (EIS product).

Specific Computers: VAX, Sun, Apollo

Level of Documentation: Standards and specifications.

Comments: EIS specifications will be independent of tools, DBMS's, platforms and operating systems. EIS is portable, distributed and adaptable to any tools or DBMS's. For demonstration purposes an EIS will be configured on several platforms with a variety of CAD tools and DBM's.

Required Resources:

Demonstration Only, None Required: Yes

Defined: N/A

Planned: N/A

Programmed: N/A

In Place: N/A

Comments:

Testing:

Scenario(s) Defined: No

Test Plan Developed: No

Comments: Test plan will be developed for the prototype demonstration only.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: Y14.26

Government Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: ANSI coordination effort.

Provide Briefings to PDES Community: Yes

Provide Results to PDES Community: Yes

Provide Contract Deliverables to PDES Community: Yes

Receive Briefings from PDES Community: Not formally.

Receive Results from PDES Community: Not formally.

Receive Project Deliverables from PDES Community: No

Comments: EIS progress and plans are regularly presented at public meetings and conferences. Mechanisms are in place for soliciting community feedback. There are a number of open SIGs designed to give the community access to EIS technical staff and reports. Several PDES participants regularly take part in these meetings.
Members of the EIS team regularly attend PDES meetings and keep the rest of the team informed. Furthermore, we are coordinating our information modeling efforts through ANSI and the IEEE.

TITLE: Geometric Modeling Applications Interface (GMAP)

RESPONSIBLE ORGANIZATION: AFSC/ASD/WRDC/MT

KEY GOVERNMENT CONTACT: Mr. Alan Winn, (513) 255-7371

CONTRACTOR: United Technologies Corporation, West Palm Beach, Florida

SHORT OBJECTIVE: The objective of the geometric modeling applications interface program is to establish and demonstrate the use of product definition in the engineering, manufacturing and logistical support of complex structural components as typified by turbine blades and disks. In addition, the project will provide valuable input to the emerging Product Data Exchange Standard (PDES) and serve to drive the overall AFLC digital data requirements specifications.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): PDDI was a precursor in demonstrating limited capability. PDES utilizes results extensively to feed to STEP. IBIS and RFC use description to drive systems.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones:

Understand Problem/Establish Requirements	
Preliminary and Detailed Design	
Integrate Functional Applications	
Build and Integrate Application Interface	July 88
Implement Maintain and Demonstrate GMAP	Aug 88
Deliverable Reports	Aug 88

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, this is a fundamental precursor project.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 1.0 and out.

Project cost by FY: ($M) - NOTE - The project is on a 70/30 cost share between government and industry.

Prior	88	89	90	91	92	outyear
4.4	1.6					

Total M/Y of effort for Government (Include MTS): 2.0

Total M/Y of effort for Contract: 45-60 cost shared.

INFORMATION SCOPE:

Class of Topical Data: The class of topical data is related to shape and size. Blueprint notes on materials are available. There is no assembly.

Class of Product: The product is of complex shaped mechanical parts, specifically turbine blades and component disks.

Product Life Cycle Target: The target is to fully design, develop, test, manufacture and support the product. The model drives various application models.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File: Yes

Active Exchange: Yes

Shared Database: No

Integrated Knowledge Base: No

Specific CAD/CAM Systems: ComputerVision, Sun

Specific Geo Modelers: GEOMOD + editor functionality.

Specific DB Enviro: DB has been developed by the contractor. It is relational.

Specific DB Modeling Tool: IDEF1X

Specific Computers: IBM 4341 which can run on VAX and Sun.

Level of Documentation: The completion of life cycle documents such as the Scoping Document, Program Management Plan/Program Master Schedule, Needs Analysis Document, System Requirements Document, System Specification and System Design Specification.

Comments: Express used for physical file work.

Required Resources:

Demonstration Only, None Required: Yes

Defined: N/A

Planned: N/A

Programmed: N/A

In Place: N/A

Comments: Project feeds implementation.

Required Procedures:

Defined: N/A

Developed: N/A

Coordinated: N/A

In Place: N/A

Comments: Technology demonstrator. No specific application procedures.

Testing:

Scenario Defined: Yes

Test Plan Developed: Yes

Comments: Testing sufficient for demonstration.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: Volunteer group and cooperative, mechanical products, integration logical layer.

Government Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: Volunteer group, mechanical products plus flow.

Provide Briefings to PDES Community: Yes

Provide Results to PDES Community: Yes

Provide Contract Deliverables to PDES Community: Yes

Receive Briefings from PDES Community: Yes

Receive Results from PDES Community: Yes

Receive Project Deliverables from PDES Community: Yes, through participation.

Comments: Industrial review board is a strong technology transfer mechanism. It provides feed forward and feedback.

TITLE: Initial Graphics Exchange Specification (IGES) Evaluation

RESPONSIBLE ORGANIZATION: PM-CALS (OSD)

KEY GOVERNMENT CONTACT: Mr. Dave Ruppe, AES-PES-CA, Fort Monmouth, New Jersey 07703, (201) 544-3170

CONTRACTOR: Computer Sciences Corporation

SHORT OBJECTIVE: The initial objective was to take a snapshot look at the DOD CALS core subset of IGES 3.0. This preliminary effort was to verify whether or not IGES problems have been solved and set up the network for later efforts. The overall project looks at the Army's capability to transfer digital data between systems, without flavoring. The follow-on effort will take a more complete look at the problem for the whole Army infrastructure, as well as contractor ability.

PUBLIC RELEASE INFO AVAILABLE: Project has been briefed at NIST CALS meetings and a recent SOLE conference.

RELATED PROJECTS (WHICH ONES & HOW): Project is being pursued under the overall CALS umbrella. PM feels that PDES is truly dependent on workable IGES (MIL-STD-1840A).

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: N/A

Major Milestones: The detailed look will be accomplished on an application (commodity) basis. Commodity specific requirements, such as bullets, electronic assemblies, etc. will be looked at in parallel over the next calendar year.

Cognizant of PDES Development Schedule:

PDES Impact Potential: No direct impact beyond infrastructure needs.

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Project cost by FY: (Manpower)

Prior	88	89	90	91	92	outyear

Total M/Y of effort for Government (Include MTS): 1 my

Total M/Y of effort for Contract: 5 my

INFORMATION SCOPE:

Class of Topical Data: The class will be a function of the commodity being investigated. For instance, tank turret construction may need to focus on 3D modeling, while electronics might deal more with topological information, etc.

Class of Product: Evaluation will look at Army commodities on a broad scale. This will include mechanical and electrical products.

Product Life Cycle Target: Principal emphasis is on design and manufacturing plus requirements for technical documentation.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File: Initially, per 1840A.

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: This evaluation will deal with the variety of CAD/CAM systems and associated software spread over the active inventory. The message is that the environment is very heterogeneous.

Required Resources: N/A

Demonstration Only, None Required:

Defined:

Planned:

Programmed:

In Place:

Comments: This project is an evaluation thus implementation resources are not required.

Required Procedures: N/A

Defined:

Developed

Coordinated:

In Place:

Comments: This project is not intended for implementation, however, it will be an active force for lessons learned which will be fed to a variety of follow-on efforts.

Testing: N/A

Scenario(s) Defined:

Test Plan Developed:

Comments: This project is an evaluation. The prime result is for lessons learned and for surfacing potential voids/problem areas which must be solved to make digital transfer a reality for the Army.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes, through corporate channels.

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: Limited to available time principally through OSD CALS.

Which Group & Subcommittee:

Provide Briefings to PDES Community: No

Provide Results to PDES Community: Yes, through NIST and hence to the volunteer group.

Provide Contract Deliverables to PDES Community: No, but see comments.

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments: A report on the snapshot activities has been prepared. Release of this initial study is pending based on the development of a list of recipients. The list is being developed by OSD.

TITLE: Integrated Design Support System (IDS)

RESPONSIBLE ORGANIZATION: AFSC/ASD/AFWAL/FIBCC

KEY GOVERNMENT CONTACT: Mr. T. N. (Nick) Bernstein, (513) 255-9729

CONTRACTOR: North American Aircraft Operations, Rockwell International Corporation

SHORT OBJECTIVE: The objectives are (1) definition of critical engineering data, (2) the integration of design, manufacturing, and logistics technical data through application of advanced computer technology so the system appears as a single database to the user. (3) the demonstration of this concept, and (4) the production of a responsive sustaining engineering database.

PUBLIC RELEASE INFO AVAILABLE: Yes, prospectus, briefing, etc. (ITAR restrictions).

RELATED PROJECTS (WHICH ONES & HOW): The IDS program is not critically dependent upon other projects. It is being developed using IDEF methodologies originally developed in the ICAM program. It is under the overall CALS umbrella and feeds associated projects.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones:

Initial Software	Sep 86
Heterogeneous System	Sep 88
Prototype IDS	Sep 90
FSD Evaluation	Sep 91

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, PDCM has configuration management potential and sustaining engineering model.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 1.0 and out.

Project cost by FY: ($M)

Prior	88	89	90	91	92	outyear
10.9	4.1	4.4	4.2	3.4		

Total M/Y of effort for Government (Include MTS): 7 my/y

Total M/Y of effort for Contract: 20 my/y

INFORMATION SCOPE:

Class of Topical Data: This project is not currently associated with any particular class of topical data. It has expended considerable effort building an overall product data control model. Plans exist to concentrate on configuration management.

Class of Product: The class deals with structural parts. The weapon system selected for this demonstration is the B-1B airframe. The technical focus is on the No. 3 wing flap and the weapons bay door. Plans exist to add some electrical product.

Product Life Cycle Target: The product life cycle targets are design and logistics.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange:

Shared Database: Yes

Integrated Knowledge Base:

Specific CAD/CAM Systems: ComputerVision, Autotrol.

Specific Geo Modelers: DI 3000 (precision visuals) for graphics.

Specific DB Enviro: Multibase, Oracle, RIM, Focus, IMS

Specific DB Modeling Tool: IDEF1X

Specific Computers: VAX 11-785, IBM 9370

Level of Documentation: At completion, a complete set of requirements and specifications will exist for FSD.

Comments: Have included knowledge-based activities in configuration management.

Required Resources:

Demonstration Only, None Required: This will provide assorted demonstrations but is actually a prototype development effort. However, no implementation resources are required.

Defined: N/A

Planned: N/A

Programmed: N/A

In Place: N/A

Comments: Looking to eventually impact ALC operations, however this would be a follow-on to the present prototype.

Required Procedures:

Defined: N/A

Developed: N/A

Coordinated: N/A

In Place: N/A

Comments: This is a prototype only, no application procedures required at this time. Plans exist to develop real applications at OC-ALC.

Testing:

Scenario(s) Defined: Has worked detailed structural repair scenarios.

Test Plan Developed: Have for prototype software but not for specific applications.

Comments: System testing plans are being developed.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: A wide variety including chairing the newly formed Product Logistics Definition committee.

Government Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Provide Briefings to PDES Community: Yes

Provide Results to PDES Community: Yes

Provide Contract Deliverables to PDES Community: Via Technical Advisory Group.

Receive Briefings from PDES Community: Not directly.

Receive Results from PDES Community: Not directly.

Receive Project Deliverables from PDES Community: No

Comments: The PDCM has been provided to the PDES body to aid the integration task. As of this time there has been no feedback.

TITLE: Integrated Information Support System (Data Automation Processor Project)

RESPONSIBLE ORGANIZATION: AFSC/ASD/WRDC/MT

KEY GOVERNMENT CONTACT: Mr. David Judson, (513-255-6976)

CONTRACTOR: Prime - Control Data Corporation, Principal Sub - Systems Dynamics Research Corporation

SHORT OBJECTIVE: Make the simultaneous and distributed functioning of different computers and data management technologies transparent to users.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): GMAP-IISS provided precursor methodology (IDEF1X). Need feedback on technical sufficiency of language to represent product data.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones: To be provided.

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, a precursor project with respect to shared data concept, IDEF1X, etc.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 1.0 and out.

Project cost by FY: ($M)

Prior	88	89	90	91	92	outyear
$20M	3.5	0	0	0	0	

Total M/Y of effort for Government (Include MTS): 1.0 remaining.

Total M/Y of effort for Contract: 250 past, plus 40 present, plus associates.

INFORMATION SCOPE:

Class of Topical Data: Not specific.

Class of Product: Not specific.

Product Life Cycle Target: Not specific.

IMPLEMENTATION:

Environment Target:

Nonspecific: No

Passive File: Yes

Active Exchange: Yes

Shared Database: Yes

Integrated Knowledge Base:

Specific CAD/CAM Systems: Sun, Appollo

Specific Geo Modelers: GEOMOD, DI3000, SSCO

Specific DB Enviro: 14 DBMS is in flat plus 4 (hierarchical, relational network, CODYSAL).

Specific DB Modeling Tool: IDEF1X & NIAM

Specific Computers: IBM, DEC, Honeywell, and look alikes.

Level of Documentation: Complete life cycle document set per MIL-STD-2167.

Comments: CDM represents a knowledge base. It is used with CDM processor to generate execution procedures for the user in the enterprise. Principal target is level 3 for DAPRO.

Required Resources:

Demonstration Only, None Required: N/A

Defined: Yes

Planned: Yes

Programmed: Yes

In Place: Yes

Comments: For pilot implementation only, Northrop, AVCO, Douglas and Materials Laboratory.

Required Procedures:

Defined: Yes

Developed: No

Coordinated: No

In Place: No

Comments: Process is in progress. Iterative approach.

Testing:

Scenario(s) Defined: Yes

Test Plan Developed: Yes

Comments: May need changes to IDEF1X or associated definition and manipulation languages.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes, (Althoff & Chia Hui Shih).

Which Group & Subcommittee: Volunteer group.

Government Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: PDE under MAP/TOP.

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: Yes

Receive Project Deliverables from PDES Community: No

Comments: Would like to brief/be briefed. Would like increased cross participation. Would like not to have to go to library for deliverables. The outline is a force fit for IISS. It is really an integrating/foundation building type project for PDES.

TITLE: Materials and parts Information Data System (MIDS)

RESPONSIBLE ORGANIZATION: US Army Materiel Command (AMCPD) DCS Production

KEY GOVERNMENT CONTACT: Mr. Richard M. Wootten (301) 394-2412

CONTRACTOR: Innovative Technology, Inc., McLean VA

SHORT OBJECTIVE: The MIDS project is to be used as a management and technical tool for providing the necessary information to aide individuals in minimizing, forecasting, and resolving item nonavailability problems by acting as a data linking/integration networking system. It will link various DOD, industry and material databases to provide application-oriented solution options to item-availability management.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): Will coordinate closely with DOD CALS as a demonstration.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes, but it is not released yet pending approval of adaptation plan.

Major Milestones:

MIDS "proof-of-concept" demonstration	Feb 1988
Preliminary assessment of MIDS adaptation to the Joint Tactical Fusing Program (JTFP) - Phase 1	Sep 1988
MIDS marketing methodology	Sep 1988
Preliminary assessment of MIDS adaptation to the AMC community	Nov 1988
Item availability data package (IADP)	Dec 1988
MIDS adaptation plan - for full AMC implementation	Jan 1989
MIDS adaptation to Joint Tactical Fusion Program plus training (phases 2 & 3 - JTFP/MIDS)	Mar 1989
MIDS test bed - CALS raster graphics transfer	Mar 1989

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Looking at impact as part of the adaptation plan.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 1.0

Project cost by FY: for general AMG adaptation to individual projects.

Prior	88	89	90	91	92	outyear
		1.7	2.2	1.9	2.1	6.5

Total M/Y of effort for Government (Include MTS): 1.0 my/yr

Total M/Y of effort for Contract: 5-7 my/yr for development

INFORMATION SCOPE:

Class of Topical Data: The MIDS focus is on item availability where an item is defined as any raw, in process or manufactured material; article; commodity; equipment; component; accessory; part; assembly; system; or product of any kind including its intrinsic/related technological information.

Class of Product: Not specific - see item definition above

Product Life Cycle Target: Aim is on availability throughout the life cycle. In large measure, logistics/support considerations predominate.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange:

Shared Database: target a linking mechanism

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: The MIDS concept is a distributed database system consisting of both geographically-distributed central control nodes and geographically-distributed autonomous nodes. The MIDS is a means to selectively choose existing information, from existing sources, using existing databases, to address existing and future problems in areas such as item nonavailability, logistics, acquisition, design, and cataloging.

Required Resources:

Demonstration Only, None Required: Yes

Defined:

Planned:

Programmed:

In Place:

Comments: The adaptation plan, which will bridge the demonstration to implementation gap. It is presently under review.

Required Procedures:

Defined:

Developed:

Coordinated:

In Place:

Comments: In work as part of the adaptation effort.

Testing:

Scenario(s) Defined:

Test Plan Developed:

Comments: In work as part of the adaptation effort.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments: Government/contractor personnel just coming up to speed on PDES activities.

TITLE: MCM-1 (Mine Counter Measures) Product Model Prototype

RESPONSIBLE ORGANIZATION: NAVSEA CEL-PA

KEY GOVERNMENT CONTACT: Mr. Jeff Arthurs, (202) 692-1530

CONTRACTOR: Construction Systems Associates (CSA), Atlanta, Georgia

SHORT OBJECTIVE: The project will develop a baseline product model that includes a 3D graphical solid representation which is interfaced with a series of other logistic and analytic files and provides a complete, integrated, and user-friendly data set for a major weapon system. Having developed the product model, exercise it across the life cycle of the ship to determine its relevant applications. Develop specifications for the delivery of a product model in the acquisition phase of a major weapon system procurement.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): Will be used in the conduct of the Navy's information systems architecture project. This prototype will form graphics core.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones: Demonstration (Phase II)-complete ship model, April 1988, Demonstration (Phase III)-link to Information System Architecture, June 1988, Preliminary Evaluation and Specification Requirements, September 1988.

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Lessons learned.

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Project cost by FY: ($M)

Prior	88	89	90	91	92	outyear
300K						

Total M/Y of effort for Government (Include MTS): .5 my/y

Total M/Y of effort for Contract: 3 my

INFORMATION SCOPE:

Class of Topical Data: Done to a level of detail (visual/graphical) to allow access to a database only. Items will be provided.

Class of Product: Includes mechanical, heating, ventilating and air conditioning equipment, etc. Again the key is level of detail.

Product Life Cycle Target: Aimed at design analysis and support. Not scheduled to work to detail required for manufacturing.

IMPLEMENTATION:

Environment Target:

Nonspecific: Yes

Passive File:

Active Exchange:

Shared Database: Goal

Integrated Knowledge Base: No

Specific CAD/CAM Systems: No CAD/CAM

Specific Geo Modelers: CSA developed modelers which can be licensed.

Specific DB Enviro: ORACLE-based.

Specific DB Modeling Tool: No information modeling done.

Specific Computers: Sun, Apollo and VAX.

Level of Documentation:

Comments: May do information modeling as part of linking to database.

Required Resources:

Demonstration Only, None Required: Yes

Defined: N/A

Planned: N/A

Programmed: N/A

In Place: N/A

Comments: Will have to install HW/SW suite in Charleston and transport model. No dollars for this in any budget.

Required Procedures:

Defined: No

Developed: No

Coordinated: No

In Place: No

Comments: Targeted at ships specification (CDRLs and DIDs). Just starting impact definition at this time.

Testing:

Scenario Defined: Yes

Test Plan Developed: Yes

Comments: The scenario focuses on using the model as a configuration/version control tool.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee: N/A

Government Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: Through NIDDESC (Navy/Industry Digital Data Exchange Standards Committee).

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments: Would like to see positive change to improve technology transfer. Working IGES portion for plant geometry. Looking at using ComputerVision system to do better than just IGES (i.e., adding some information content).

TITLE: Microcircuit Emulation Program (MEP)

RESPONSIBLE ORGANIZATION: DLA Manufacturing Engineering/Research Office (DME/RO)

KEY GOVERNMENT CONTACT: Mr. Don O'Brien (202) 274-6445

CONTRACTOR: Stanford Research Institute, Science Applications International Corporation and the Institute for Technology Development.

SHORT OBJECTIVE: To provide form, fit and function replacements for obsolete microcircuits. The key is developing a proper circuit characterization such that engineers can design a new one with the same functions. Obsolete circuits are divided into families/groups that can be emulated by one chip per family. The chip uses software to provide circuit unique features.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): None

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Being revised.

Major Milestones:

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential:

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Project cost by FY: $ Mil

Prior	88	89	90	91	92	outyear
4.2	4.1	4.3	4.3	4.3	4.3	4.3

Total M/Y of effort for Government (Include MTS):

Total M/Y of effort for Contract:

INFORMATION SCOPE:

Class of Topical Data: Complete functional specifications of microcircuits including process specific variables.

Class of Product: Electronic microcircuitry.

Product Life Cycle Target: Manufacturing support for repair of old systems.

IMPLEMENTATION:

Environment Target: N/A

Nonspecific:

Passive File:

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: Program is for chip delivery, not a software implementation.

Required Resources: N/A

Demonstration Only, None Required:

Defined:

Planned:

Programmed:

In Place:

Comments:

Required Procedures: N/A

Defined:

Developed:

Coordinated:

In Place:

Comments:

Testing: N/A

Scenario(s) Defined:

Test Plan Developed:

Comments:

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments: Not interacting with the PDES community at this time.

TITLE: Military Parts Control Advisory Group (MPCAG) Parts Information System (MPIS)

RESPONSIBLE ORGANIZATION: DLA-S, Directorate of Technical and Logistics Services

KEY GOVERNMENT CONTACT: Mr. Willis Drake (202) 274-6775

CONTRACTOR: Logistics Management Institute (LMI), Bethesda MD.

SHORT OBJECTIVE: Provide, via the DTIC Gateway System, access by industry and military activities to databases which are an inherent part of the Military Standard 965 Parts Control process. The information transferred are the Government Furnished Baselines.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): Modernization Parts Control Automated Support System (MPCASS) will use demonstration results.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: yes (project plan)

Major Milestones:

Project initiation	Oct 1987
1st Deliverable	
Bring system on-line	
Test system	
Develop final report	Dec 1988

Cognizant of PDES Development Schedule:

PDES Impact Potential:

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Project cost by FY:

Prior	88	89	90	91	92	outyear
	150K	50K				

Total M/Y of effort for Government (Include MTS):

Total M/Y of effort for Contract:

INFORMATION SCOPE:

Class of Topical Data: Baseline of approved parts.

Class of Product: Not specific.

Product Life Cycle Target: MPIS is a demonstration project and the system is planned to be overtaken by the MPCASS when MPCASS is implemented. It is in support of standard parts activity.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro: Relational Database.

Specific DB Modeling Tool:

Specific Computers: Pyramid through DTIC.

Level of Documentation:

Comments: Produces a particular menu driven database implementation.

Required Resources:

Demonstration Only, None Required: Yes

Defined:

Planned:

Programmed:

In Place:

Comments:

Required Procedures:

Defined:

Developed:

Coordinated:

In Place:

Comments: Questionnaire developed and forwarded to participating contractors for their feedback on the overall functional, operational and effectiveness of the MPIS. The Questionnaire also addressed the format and structure of the user's manual. A user's manual was developed.

Testing:

Scenario(s) Defined: System tested with DLA users (MPCAGS) prior to making the MPIS available to participating contractors.

Test Plan Developed: Informally, the MPIS was developed as a prototype system.

Capabilities Demonstrated: Yes, system meets the stated requirement (goal) of providing Government Furnished Baseline information data via the gateway to contractors.

Comments:

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments:

TITLE: Navy Computer Aided Design Second Acquisition (CAD II)

RESPONSIBLE ORGANIZATION: Naval Data Automation Command, Navy CAD/CAM Program Office (NAVDAC PMD-1)

KEY GOVERNMENT CONTACT: Mr. Dale Christensen, (202) 433-7242

CONTRACTOR: This project is in the pre-award phase.

SHORT OBJECTIVE: The CAD II project will put in place a series of umbrella contracts to allow the Navy System Commands to acquire standardized CAD/CAM systems. Multiple awards are anticipated. The umbrella contracts will be available DOD-wide if desired. This indicates the potential of a wide installed base.

PUBLIC RELEASE INFO AVAILABLE: Yes, draft specifications.

RELATED PROJECTS (WHICH ONES & HOW): The CAD II project is contingent upon and directly interfaces the Navy CALS effort.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: In draft.

Major Milestones: (1) Draft RFP release, (2) RFP release, (3) RFP closure, (4) Technical evaluation, which includes live test demonstration, and (5) Contract award.

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, for potential vendor interest.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): All

Project cost by FY: (subset of total) $M

Prior	88	89	90	91	92	outyear

Total M/Y of effort for Government (Include MTS): 250

Total M/Y of effort for Contract: Not yet on contract.

INFORMATION SCOPE:

Class of Topical Data: As the title indicates, the project is CAD intensive, initial primary function is geometry related. However, ancillary data such as physical and functional characteristics are also important.

Class of Product: The ultimate goal is to use the systems with a complete, assembled product such as a ship or an airplane. Thus the intended class of product is extremely broad.

Product Life Cycle Target: Initial focus is design. Will eventually span the total life cycle. The Navy notes that an overhaul in reality is often a new design.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File: Start here with progress to active exchange.

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: Not yet on contract. System specifics will come as part of the overall acquisition.

Required Resources:

Demonstration Only, None Required: N/A

Defined: Yes

Planned: Yes

Programmed: Yes

In Place:

Comments: CAD systems will be purchased from program and "industrial" funds as required. Thus, resources are part of system funding lines.

Required Procedures:

Defined: Yes

Developed: Yes

Coordinated: Yes

In Place:

Comments: Some procedures have been defined. The potential for scale-up problems must be investigated.

Testing:

Scenario(s) Defined: No

Test Plan Developed: No

Comments: Live testing will be part of source selection and first article acceptance. Specific scenarios will be defined to support the acquisition process.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities:

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: Yes, through NIST.

Which Group & Subcommittee: Focus is with IGES group.

Provide Briefings to PDES Community:

Provide Results to PDES Community:

Provide Contract Deliverables to PDES Community:

Receive Briefings from PDES Community:

Receive Results from PDES Community:

Receive Project Deliverables from PDES Community:

Comments: Since the project is in the pre-award phase, technology transfer is just being defined. It is the intention to disseminate and receive results with the PDES community.

TITLE: Product Definition Initiative (PDI)

RESPONSIBLE ORGANIZATION: Lawrence Livermore National Laboratory, Mr. Derek Wopman, (415) 543-0826

KEY GOVERNMENT CONTACT: Department of Energy - Albuquerque Operations Office, Mr. G. Stanley Hearron, (505) 846-5311

CONTRACTOR: DOE internal

SHORT OBJECTIVE: (1) Define Nuclear Weapons Complex (NWC) product definition. (2) Demonstrate the exchange and use of NWC product definition. (3) Recommend a path for production-worthy implementation of NWC product definition.

PUBLIC RELEASE INFO AVAILABLE: No

RELATED PROJECTS (WHICH ONES & HOW):

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: No

Major Milestones: Milestones relate to the development of tested integrated models. Application models are first developed then integrated for mechanical parts (per areas shown in product class).

Cognizant of PDES Development Schedule: Yes, but not critically dependent.

PDES Impact Potential: Yes, directly incorporated model

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 1.0 and out

Project cost by FY: (subset of total) $M

Prior	88	89	90	91	92	outyear

Total M/Y of effort for Government (Include MTS): 14 FTEs

Total M/Y of effort for Contract: N/A

INFORMATION SCOPE:

Class of Topical Data: Application area driven.

Class of Product: Form features, drafting, numerical control, tooling, and inspection are integrated and applied to mechanical parts.

Product Life Cycle Target: Total product lifecycle, design to retirement.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange:

Shared Database:

Integrated Knowledge Base: Yes

Specific CAD/CAM Systems: No

Specific Geo Modelers: No

Specific DB Enviro: No

Specific DB Modeling Tool: NIAM, IDEF1X

Specific Computers: No

Level of Documentation:

Comments:

Required Resources:

Demonstration Only, None Required:

Defined: No

Planned: No

Programmed: No

In Place: No

Comments: In start-up phase.

Required Procedures:

Defined: No

Developed: No

Coordinated: No

In Place: No

Comments: In start-up phase.

Testing:

Scenario(s) Defined: No

Test Plan Developed: No

Comments: In start-up phase.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: N/A

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: Yes, intimately.

Which Group & Subcommittee: Form features, drafting, solids, FEA, IGES, mechanical products, electrical products.

Provide Briefings to PDES Community: No

Provide Results to PDES Community: Yes

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: Yes

Receive Project Deliverables from PDES Community: No

Comments: PDI drafting model will virtually be the PDES drafting model.

TITLE: Rapid Acquisition of Manufactured Parts (RAMP)

RESPONSIBLE ORGANIZATION: Naval Supply Systems Command PML5505M

KEY GOVERNMENT CONTACT: Ms. Lorna B. Estep, (202) 697-4561/62, AV 227-4561/62)

CONTRACTOR: South Carolina Research Authority

SHORT OBJECTIVE: Use computer integrating manufacturing techniques to reduce lead-time and cost of low demand parts. Address small mechanical parts (SMP) and printed wiring assemblies (PWA) with intention of transferring technology to small and midsize manufacturers.

PUBLIC RELEASE INFO AVAILABLE: Video tapes and briefings.

RELATED PROJECTS (WHICH ONES & HOW): Part Digitizing Systems (PARDS) Laser Scanner for putting mechanical part into Computer Vision CAD system. Going to NIST temporarily for use in PDES applications.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones:

	Small Mech Parts	Printed Wiring Assemblies
Preliminary Design Review	Mar 88	Apr 88
Critical Design Review	Aug 88	Dec 88
Test	Mar 90	Jul 90
Initial Operating Capability	Jul 90	Dec 90

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: No direct impact. Will use PDES like files. Potential for test sights.

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Project cost by FY: ($M)

Prior	88	89	90	91	92	outyear
23.5	18	8.3	4.7			

Total M/Y of effort for Government (Include MTS): 8 MTS, 7 Gov

Total M/Y of effort for Contract: 160

INFORMATION SCOPE:

Class of Topical Data: APPLICATIONS - material ordering, assembly, cutting, inspection, testing; DATA - physical dimensions, bill of materials, tolerances, MIL SPECS and standards.

Class of Product: Mechanical parts (less than 24 x 21 x 16). Printed wiring assemblies (solid state, non-microwave).

Product Life Cycle Target: Manufacturing support including material ordering, process planning, NC generation, inspection and testing.

IMPLEMENTATION:

Environment Target:

Nonspecific: No

Passive File: Yes

Active Exchange: No

Shared Database: No

Integrated Knowledge Base: No

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: Levels and vendors for implementation have not been determined at this time. They will be influenced by speed and sophistication of vendors used in developing applications to access data.

Required Resources:

Demonstration Only, None Required: N/A

Defined: Yes

Planned: No

Programmed: No

In Place: No

Comments: Planning and programming will be accomplished with NAVORDSTA, Louisville and NWSC, and Crane, once they are approved as SMP and PWA PDES development sites respectively.

Required Procedures:

Defined: Yes

Developed: No

Coordinated: No

In Place: No

Comments: Procedures will be developed with PDES SMP site, NAVORDSTA, Louisville and PDES PWA site, NWSC, and Crane upon NAVSEA approval of their participation with RAMP.

Testing:

Scenario(s) Defined: Yes

Test Plan Developed: No

Comments: Test and evaluation plan has been developed for RAMP, not for incoming PDES validation.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Grumman Data Systems, Mr. Pete Everitt.

Which Group & Subcommittee: Manufacturing, tolerances and physical file.

Government Personnel Actively Participate in PDES Activities: NIST Automated Manufacturing Research Facility (AMRF).

Which Group & Subcommittee: IGES/PDES committee.

Provide Briefings to PDES Community: Yes

Provide Contract Deliverables to PDES Community: Yes

Receive Briefings from PDES Community: Yes

Receive Results from PDES Community: Yes

Receive Project Deliverables from PDES Community: Yes

Comments: NIST through the AMRF conducts reviews and testing for RAMP. This provides a direct link to the IGES/PDES community.

TITLE: Seawolf Advanced Submarine Acquisition Program

RESPONSIBLE ORGANIZATION: NAVSEA PMS 350

KEY GOVERNMENT CONTACT: LCDR Blaine Brucker, (202) 692-1888

CONTRACTOR: Newport News Shipbuilding plus a number of subcontractors.

SHORT OBJECTIVE: Design and construct Seawolf class submarines and in so doing, insure transfer of non-processible text (word processing, etc.), processible text (database, etc.), 2D drawings and 3D product models.

PUBLIC RELEASE INFO AVAILABLE: No

RELATED PROJECTS (WHICH ONES & HOW): There are no direct dependencies.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Internal Navy only.

Major Milestones: Construction contract award November 1988. Construction start April 1989.

Cognizant of PDES Development Schedule: Yes, but not driven by the schedule. There is no flow forward.

PDES Impact Potential: Lessons learned and infrastructure.

Specifics (Version 1.0, 2.0, 3.0, later, etc.):

Project cost by FY: Rough estimate only available.

Prior	88	89	90	91	92	outyear

Total M/Y of effort for Government (Include MTS):

Total M/Y of effort for Contract: Approximately 8 my/year level load.

INFORMATION SCOPE:

Class of Topical Data: No particular class of topical data.

Class of Product: The primary thrust is for piping and structure. This is based upon a cost-effectiveness measure which indicates the potential for significant savings in these areas. Will eventually include ventilation and machinery.

Product Life Cycle Target: Primary thrust is for the manufacturing portion of the life cycle. Will also interface and utilize a consolidated logistics database for eventual support activity.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File: Yes

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems: Primary systems are ComputerVision and CADAM.

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers:

Level of Documentation:

Comments: Seawolf is being designed using on the order of 400 CAD stations. The environment is thoroughly heterogeneous. Plans call for 100% use of CAD vice drawing using the board.

Required Resources:

Demonstration Only, None Required:

Defined: Yes

Planned: Yes

Programmed: Yes

In Place: Yes

Comments:

Required Procedures:

Defined: Yes

Developed: Yes

Coordinated: Yes

In Place: Yes

Comments: The procedures are in place for data, drawing, and model transfer. These will be revised as lessons are learned during the execution of the Seawolf program.

Testing:

Scenario(s) Defined: Yes

Test Plan Developed: Yes

Comments: The Seawolf class submarines are not yet under construction. Transfer of full-up drawings (10-12 pages) is undergoing loop testing on a demonstration basis. These will be final testing prior to construction.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: N/A

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Provide Briefings to PDES Community:

Provide Results to PDES Community:

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community:

Comments: This program is not waiting for PDES. It will use IGES extensively until such time as PDES is ready. Comments provided indicated that shipbuilding input is necessary for PDES development. This program is a source of significant lessons learned information.

TITLE: Technical Management Information System (TMIS)

RESPONSIBLE ORGANIZATION: NASA Space Station Program Office

KEY GOVERNMENT CONTACT: Mr. Tim Rau, (703) 487-7171

CONTRACTOR: System integration contractor is Boeing Computer Services

SHORT OBJECTIVE: Provide the tools and rules to the space station program to enable design, development, management, operations and support.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): NASA Program Communication Support Network provides the conduit for information flow. The Administrative Information Management Council provides standards for administrative (e.g. payroll, inventory control, etc.) systems.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones: Phased implementation for operational readiness. Each site will have individual PDR, CDR, etc. as each goes through the cycle leading to IOC.

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Yes, as an implementation.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 1.0, NOTE - The published Interface Definition Document defines a PDES connect starting with Version 1.0.

Project cost by FY: (PDES related subset of total program) $M

Prior	88	89	90	91	92	outyear
4.0	2.0	24.0	60	TBD		

Total M/Y of effort for Government (Include MTS): 6 my to date.

Total M/Y of effort for Contract: Rate is now 4 my/y which implies 30 to 40 over life of TMIS. There will be additional manpower from subcontractors.

INFORMATION SCOPE:

Class of Topical Data: Look for integration level models and CAD/CAM applications at the center level - need all topics. Will archive data for later use.

Class of Product: Will eventually encompass all.

Product Life Cycle Target: All. Lasts through 30 year life of the space station.

IMPLEMENTATION:

Environment Target:

Nonspecific:

Passive File:

Active Exchange: Yes

Shared Database: No

Integrated Knowledge Base: No

Specific CAD/CAM Systems: SDRC IDEAS, INTERGRAPH, CALMA, MCAUTO, CATIA, CADAM.

Specific Geo Modelers: IDEAS is predominant.

Specific DB Enviro: Relational, Oracle plus some other environments embedded in CAD.

Specific DB Modeling Tool:

Specific Computers: IBM, DEC, CDC

Level of Documentation: MIL Standard will be used.

Comments:

Required Resources:

Demonstration Only, None Required:

Defined: Yes

Planned: Yes

Programmed: Yes

In Place: Will be

Comments: Budget cuts will potentially impact implementation.

Required Procedures:

Defined: Conceptually

Developed: No

Coordinated: No

In Place: No

Comments: Still a bit in a state of flux during design and development.

Testing:

Scenario(s) Defined: No

Test Plan Developed: No

Comments: Still in development. Will be in place by 4th quarter of FY88.

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: Unsure

Government Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments: Participation is tangential through the integration contractor.

TITLE: University of Utah ALPHA-1 Solid Modeling System

RESPONSIBLE ORGANIZATION: DARPA/ISTO

KEY GOVERNMENT CONTACT: Mr. Pete Brown, National Institute of Standards and Technology (NIST), (301) 975-3513

CONTRACTOR: University of Utah, Principal Investigators Rich Riesenfeld and Elaine Cohen, Computer Science Department, 3190 Merrill Engineering Building, Salt Lake City, Utah 84112

SHORT OBJECTIVE: The ALPHA-1 experimental geometric modeling testbed is designed to support integrated research in computer aided geometric design and manufacture. The system supports solid modeling, N/C code generation, and finite element analysis (mesh generation).

PUBLIC RELEASE INFO AVAILABLE: Informtion is available.

RELATED PROJECTS (WHICH ONES & HOW): DARPA Stanford First Cut, Cornell and NIST. Contact Mr. William E. Isler at DARPA, (202) 694-4001, ARPANET:isler@vax.darpa.mil. These systems will be used to investigate an integrated product life-cycle design system.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: No

Major Milestones: Development of ALPHA-1 and release to government labs and companies for testing. The goals of the selected testing is to point out areas of strengths and weaknesses, and to suggest further development.

Cognizant of PDES Development Schedule: Unknown

PDES Impact Potential: Design integration from research perspective.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): Much of the work will support the general requirements found in PDES version 1.0. It could potentially fit into several of the levels. Many of the issues deal with support of integration of design and manufacturing so should be considered looking towards future versions. In terms of the appropriate level this system deals with the shared database and integrated knowledge base levels. DAPRA desires that this research project and others related to it should have a close working relationship with the PDES effort.

Project cost by FY: (subset of total) $M

Prior	88	89	90	91	92	outyear

Total M/Y of effort for Government (Include MTS):

Total M/Y of effort for Contract:

INFORMATION SCOPE: ALPHA-1 could be used in several areas of the product life cycle. These include during (1) the initial design phase to describe the geometry of the product, (2) the analysis phase by developing a finite element mesh, and (3) during the manufacturing phase for the development of N/C code.

Class of Topical Data:

Class of Product: ALPHA-1 is a solid modeling system, primarily useful in defining mechanical products. However, it could be used to represent the physical characteristics (size and shape of components) of others such as a circuit board.

Product Life Cycle Target: ALPHA-1 provides shape or solid modeling tools useful throughout the product life cycle.

IMPLEMENTATION:

Environment Target: The current implementation of ALPHA-1 would be useful in supporting the passive and active file mechanisms. The product could be represented in a file form and passed to other applications. Because of its implementation it has the potential to support integrated knowledge base concepts as well. In the DARPA project all of the participants will use ALPHA-1 in some form.

Nonspecific:

Passive File:

Active Exchange:

Shared Database:

Integrated Knowledge Base: With the use of the Hyperclass systems by First Cut and potentially NIST and Cornell, this level of PDES could be supported. In addition, ALPHA-1 is built with an object oriented paradigm so it will fit well at this level.

Specific CAD/CAM Systems:

Specific Geo Modelers: ALPHA-1 is a solid modeling system that supports the generation of geometric primitives such as lines, arcs, etc., and surfaces and solids. It is a spline-based modeler.

Specific DB Enviro: ALPHA-1 has its own set of internal storage tools. It does not make use of conventional DBMS.

Specific DB Modeling Tool:

Specific Computers: ALPHA-1 runs on a variety of engineering workstations. Apollo, Sun, Silicon Graphics, H-P. On several of the systems (Sun and Apollo) they support the X-window system.

On the Silicon Graphics and the H-P they make some use of the graphics hardware.

Level of Documentation: System documentation exists. No in-depth review at this time. It does contain information about the use of the system, internals and function calls and their arguments.

Comments: ALPHA-1 has been developed in C and Portable Standard Lisp (PSL) from the University of Utah.

Required Resources:

Demonstration Only, None Required: Yes

Defined:

Planned:

Programmed:

In Place:

Comments: The system requires a workstation with sufficient memory (approximately 12-16 megabytes) and disk space on the order of 50 megabytes. Color graphics is also required.

Required Procedures:

Defined: N/A

Developed: N/A

Coordinated: N/A

In Place:

Comments: The ALPHA-1 system is a research project on advanced solid modeling concepts and the relationship of capturing and representing complex geometric shapes. This information is used during the design, analysis and manufacturing. The results will most likely help in moving future versions of PDES towards complete product life cycle definition.

Testing:

Scenario(s) Defined: No

Test Plan Developed: No

Comments:

TECHNOLOGY TRANSFER: DARPA has established a National Institute of Standards and Technology (NIST)-University group to investigate research topics in the area of design for manufacturing and product life-cycle definition. NIST is the site of the voluntary PDES work, it is involved with industry consortiums, and will head a OASD national PDES testbed effort. Several of the University projects are part of the NSF Engineering Research Centers as well as having numerous industrial partners.

Contractor Personnel Actively Participate in PDES Activities:

Which Group & Subcommittee: No

Government Personnel Actively Participate in PDES Activities: Yes, through NIST.

Which Group & Subcommittee:

Provide Briefings to PDES Community: No

Provide Results to PDES Community: No

Provide Contract Deliverables to PDES Community: No

Receive Briefings from PDES Community: No

Receive Results from PDES Community: No

Receive Project Deliverables from PDES Community: No

Comments:

TITLE: VHSIC Hardware Description Language (VHDL)

RESPONSIBLE ORGANIZATION: AFSC/ASD/AFWAL/AADE

KEY GOVERNMENT CONTACT: Dr. John Hines, (513) 255-4448

CONTRACTOR: Intermetrics

SHORT OBJECTIVE: Develop a standard hardware description language for the structure and behavior of digital electronic circuits. Develop a set of software tools which utilize the VHDL language. These include an analyzer, simulator, design library manager, and graphical interface.

PUBLIC RELEASE INFO AVAILABLE: Yes

RELATED PROJECTS (WHICH ONES & HOW): Engineering Information System (EIS) using VHDL, developing information model for VHDL; IDAS developing several CAD tools which utilize VHDL as a primary design language.

COST & SCHEDULE CONSIDERATIONS:

Development Schedule Published: Yes

Major Milestones:

VHDL becomes IEEE standard 1076-1987	Dec 1987
1076 language analyzer, simulator, design library manager complete	Apr 1988

Cognizant of PDES Development Schedule: Yes

PDES Impact Potential: Lessons learned potential.

Specifics (Version 1.0, 2.0, 3.0, later, etc.): 1.0

Project cost by FY: (subset of total) $M

Prior	88	89	90	91	92	outyear
14	1.4	0.1				

Total M/Y of effort for Government (Include MTS): 20

Total M/Y of effort for Contract: 100

INFORMATION SCOPE:

Class of Topical Data: Behavior, structure, configuration. User defined attributes can be used to describe any other features.

Class of Product: Digital electronic circuits and systems are the main focus. Other systems can also be described.

Product Life Cycle Target: Specification, design, analysis, test, support.

IMPLEMENTATION:

Environment Target:

Nonspecific: Yes

Passive File:

Active Exchange:

Shared Database:

Integrated Knowledge Base:

Specific CAD/CAM Systems:

Specific Geo Modelers:

Specific DB Enviro:

Specific DB Modeling Tool:

Specific Computers: VAX, VMS, UNIX, IBM

Level of Documentation: Language reference manual software user's guide and detailed design documents.

Comments: The VHDL language is environment independent. Government developed tools run on VMS, UNIX and IBM. Other commercially developed tools will run on a variety of platforms.

Required Resources:

Demonstration Only, None Required:

Defined: N/A

Planned: N/A

Programmed: N/A

In Place: N/A

Comments:

Required Procedures:

Defined: N/A

Developed: N/A

Coordinated: N/A

In Place: N/A

Comments:

Testing:

Scenario(s) Defined: No

Test Plan Developed: No

Comments:

TECHNOLOGY TRANSFER:

Contractor Personnel Actively Participate in PDES Activities: No

Which Group & Subcommittee:

Government Personnel Actively Participate in PDES Activities: Yes

Which Group & Subcommittee: ANSI coordination effort.

Provide Briefings to PDES Community: Yes

Provide Results to PDES Community: Yes

Provide Contract Deliverables to PDES Community: Available to general public.

Receive Briefings from PDES Community: Yes

Receive Results from PDES Community: Yes

Receive Project Deliverables from PDES Community: No

Comments:

APPENDIX B

PARTICIPATION

This document took shape as a result of formal meeting activities and informal staff reviews. The formal activities were: (1) Task Group Meeting of 26 January 1988, (2) Expert Group Session of 21-22 March 1988, and (3) Task Group Meeting of 21-22 April 1988. Participants in these activities were as follows:

NAME	ORGANIZATION	(1)	(2)	(3)
Mr. Bill Alzheimer	Sandia National Labs	X		X
Mr. Jeff Arthurs	NAVSEA CEL-PA	X		
Mr. Howard Bloom	Nat'l Inst of Stds & Tech	X		
LCDR Blaine Brucker	PMS350-Seawolf (SSN21)			X
Ms. Kathleen Connelly	Boeing/TMIS Project			X
Mr. Ken Crouse	NASA/Johnson Space Center	X		
Dr. Gary L. Denman	WRDC/CD	X		X
Mr. Gabe DiGiovanni	NAVSEA PMS 350A12	X		
Mr. Don Doak	Sandia National Labs	X	X	X
Ms. Cita Furlani	Nat'l Inst of Stds & Tech		X	X
Mr. Gregory L. Griffin	AFSC/PLXC (AF CALS Office)	X		X
Mr. Don Hall	OSD P&L			X
Mr. Randy J. Harrison	Sandia National Labs		X	
Mr. Jay Hay	SDRC		X	
Mr. G. Stanley Hearron	US DOE/AL	X		X
Dr. William M. Henghold	Universal Technology Corp	X	X	X
Dr. Merrill Hessel	Nat'l Inst of Stds & Tech	X		
Dr. William E. Isler	DARPA/ISTO	X		X
Mr. Jon Judd	ITI		X	
Mr. J. C. Kelly	Sandia National Labs		X	
Dr. Albert L. Klosterman	SDRC		X	
Mr. Melvin S. Lammers	HQ AFLC/SCTA	X	X	
Mr. Bruce Lepisto	OSD P&L			X
Mr. James Mays	Naval Supply Systems (PML5505M)	X		X
Mr. Stephen McGlone	US Army Ind Eng Activity	X		
Dr. Mike McGrath	OSD-CALS	X		
Mr. Don Naify	AFSC/PLXC			X
Mr. Leo Plonsky	NAVIRSA	X		
Mr. George Pogharian	DLA-DCLSO	X		
Mr. Timothy Rau	NASA/Space Station TMIS	X		X
Mr. Robert Rosen	Harry Diamond Labs			X
Mr. George C. Salley	Boeing/TMIS Project	X		
Mr. Mark Seelhammer	US Army Ind Eng Activity	X		
Mr. Russell R. Shorey	OSD P&L	X		X
Mr. Gerald Shumaker	WRDC/MT	X	X	X
Mr. Bradford Smith	Nat'l Inst of Stds & Tech	X		X
Ms. Jo Smith	HQ AFLC/SCTAI		X	
Mr. Neil Snodgrass	D. Appleton Company, Inc.		X	

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